SFCTA Contract Number 06/07-29

Caltrans EA Number 04-163701

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE

DOYLE DRIVE

DOYLE DRIVE REPLACEMENT PROJECT

Low Causeway

Hydraulics Report

February 2009

Revised July 2009

Prepared By:

Arup PB Joint Venture

This Low Causeway Hydraulics Report has been prepared under the direction of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and the engineering data upon which the recommendations, conclusions and decisions are based.

Bori A. Touray

BORI TOURAY
REGISTERED CIVIL ENGINEER

July 29, 2009

DATE

California Department
Transportation District 4

Doyle Drive Replacement Project

Low Causeway
Hydraulics Report

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1 Introduction

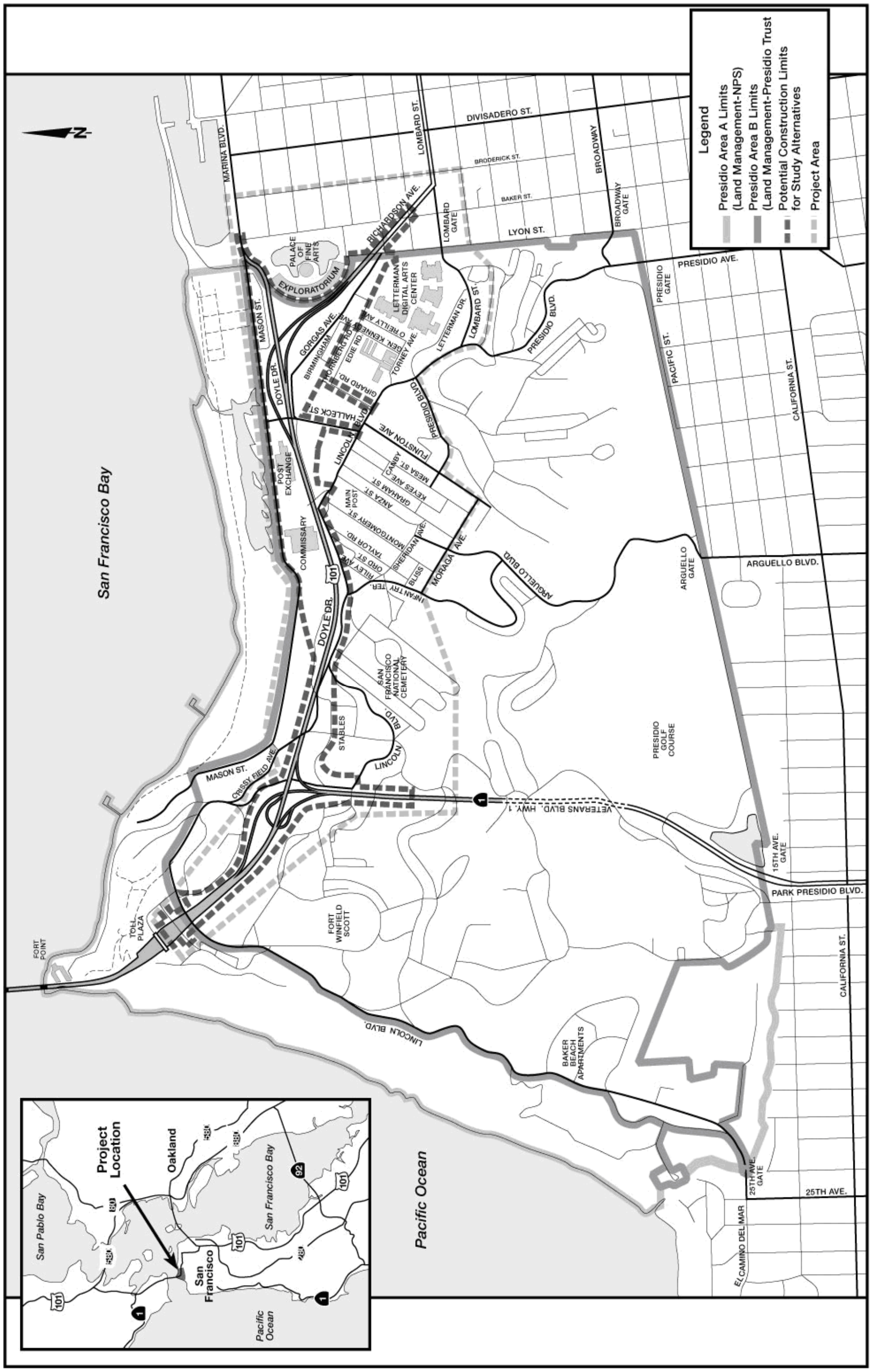
1.1 Purpose

The Caltrans “Office of Special Funded Projects (OSFP) Information and Procedures Guide” requires that a separate hydraulic report be prepared for each structure in, over or adjacent to streams and waterways which may affect the design or construction of structures (Reference 1). The proposed Doyle drive Low Causeway will span across the proposed Tennessee Hollow Creek restoration. Under existing conditions, there is no natural stream as the channel has been covered over and the runoff is conveyed in storm drains and as surface runoff. This report determines the water surface elevations, velocities and potential scour depths at the piers for the proposed Low Causeway. The scour depths is this report are preliminary and is not to be used for because the geotechnical information required for estimation of scour depths was not available at the time of writing of this report. The expenditure authorization is EA 163701.

1.2 Background

Doyle Drive Replacement Project is 1.5 linear miles and is the southern approach of Route 101 to the Golden Gate Bridge in Caltrans District 4, San Francisco County (Figure 1). Doyle Drive is approaching the end of its useful life after over 70 years of operation. In the short-term, regular maintenance, seismic retrofit, and rehabilitation activities are keeping the structure safe. In the long-term, permanent improvements are needed to bring Doyle Drive up to current design and safety standards. The San Francisco Board of Supervisors recommended that Caltrans develop a scheme that would improve safety and not increase the number of vehicles using Doyle Drive.

Figure 1: Location Map

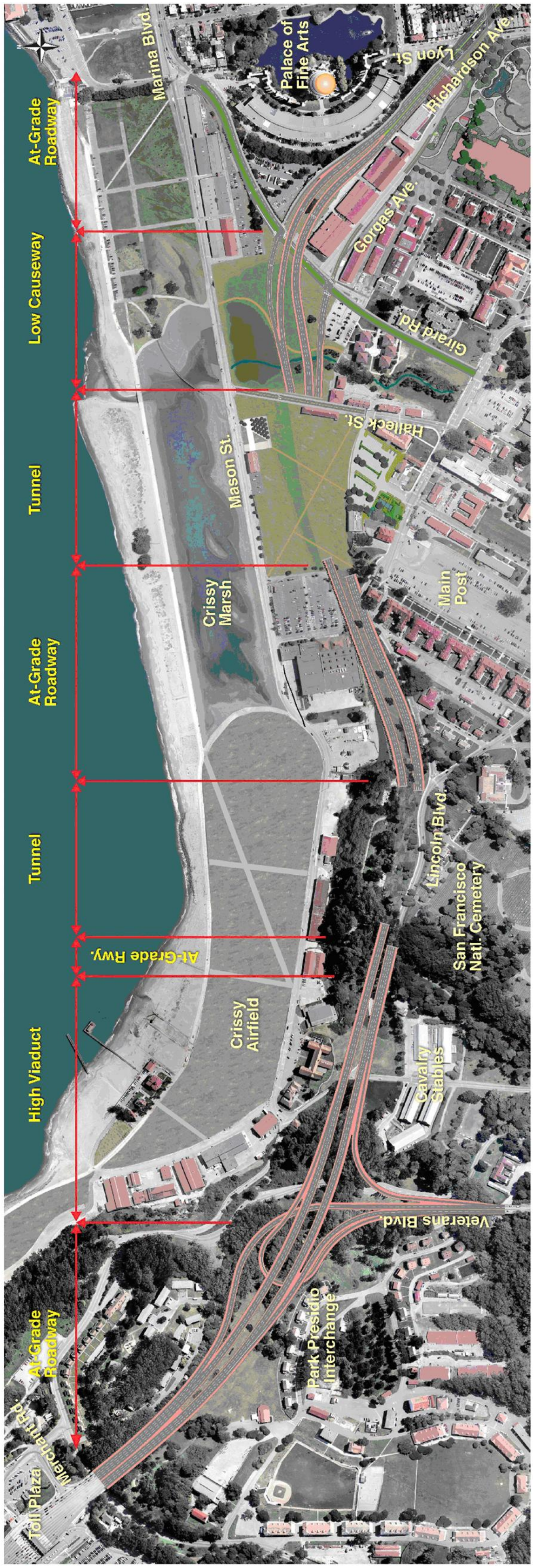


2 Preferred Alternative

The preferred alternative will replace the existing roadway with a new six-lane facility and a southbound auxiliary lane, between the Park Presidio Interchange and the new Presidio access at Girard Road (Figure 2). The new facility will consist of two 11-foot lanes and one 12-foot outside lane in each direction with 10-foot outside shoulders and 4-foot inside shoulders. In addition, an 11-foot auxiliary lane runs along southbound Doyle Drive from the Park Presidio Interchange to the Girard Road exit ramp. The total roadway width will be 105 feet and the overall facility width including the median will vary from 122 to 146 feet. The width of the proposed landscaped median varies from 16 feet to 41 feet. To minimize impacts to the area, the footprint of the new facility will include a large portion of the existing facility's footprint east of the Park Presidio Interchange. The existing elevated Doyle Drive is supported by bents that are located approximately every 31 feet along the alignment. The lateral spacing of the bents will increase to approximately 100 feet.

The preferred alternative includes a low causeway across Tennessee Hollow Creek at Post-Mile 8.28 to 8.35. From Halleck Street, Doyle Drive will rise slightly on a low causeway 525 feet long over the site of the proposed Tennessee Hollow restoration and a depressed Girard Road. The low causeway will rise to approximately 13 feet above the surrounding ground surface at its highest point. East of Girard Road the facility will return to existing grade north of the Gorgas warehouses and connect to Richardson Avenue.

Figure 2: Preferred Alternative



3 Hydrologic Analysis

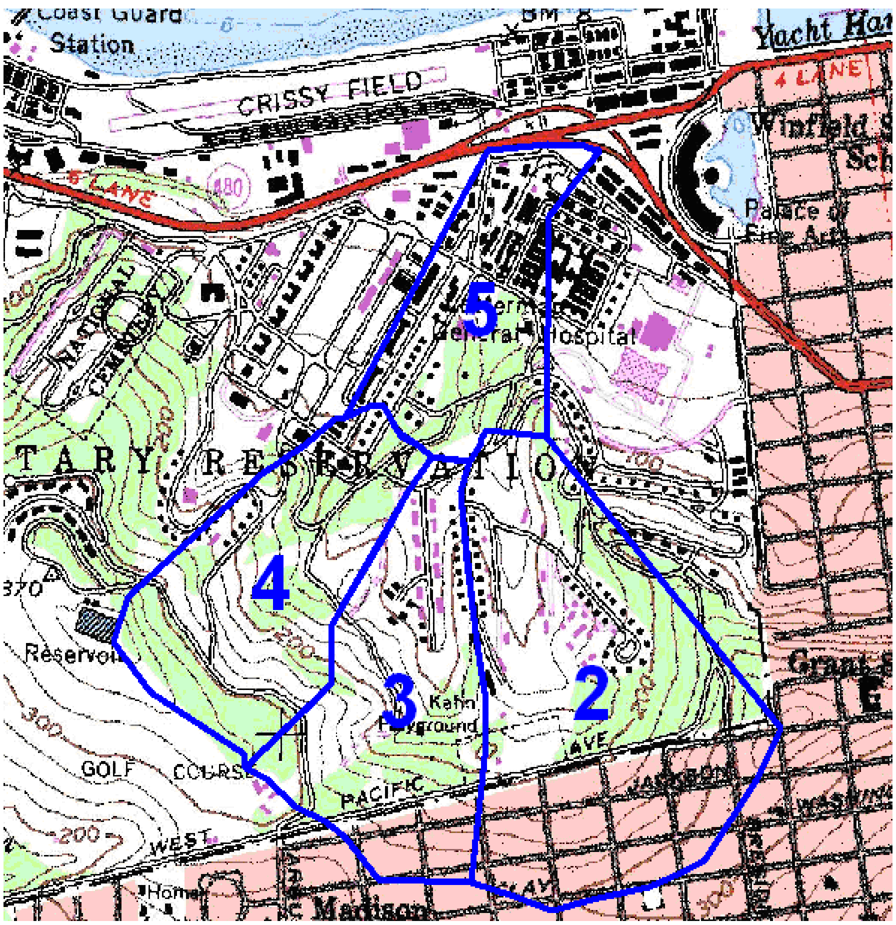
3.1 Approach

The US Army Corps of Engineers' HEC-HMS computer program was used to compute the 2-, 10-, 25-, 50-, 100- and 500-year watershed runoff. The program is designed to simulate the precipitation-runoff processes of dendritic watershed systems. It is designed to be applicable in a wide range of geographic areas for solving the widest possible range of problems. HEC-HMS is applicable for the analysis at the Doyle Drive site.

3.2 Watershed Description

The watershed draining to the Tennessee Hollow creek consists of approximately 357 acres of various land uses, including open space, residential, commercial, industrial, and institutional. The watershed was delineated on USGS quadrangle map (Figure 3).

Figure 3: Tennessee Hollow Creek Watershed



There are no open channel creeks or streams that cross the current Doyle Drive alignment. The majority of the drainage in the urban areas occurs through the Presidio storm drain system in an underground pipe network and in open channels parallel to roads. The watershed is covered by approximately 35 acres of impervious surfaces (i.e., roads, parking lots, and buildings) (Figure 4).

Figure 4: Land use

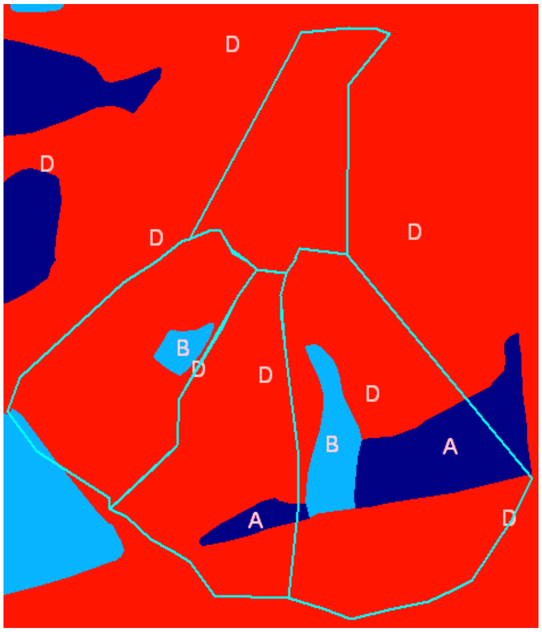
The rain gage for San Francisco City, Gage No. E70 7772 00, with over 116 years of data was used for analyzing the runoff from the watershed. The rainfall data was obtained from the California Department of Water Resources website (Appendix A). The Natural Resource Conservation Service Hydrologic Soil Groups and curve number procedure were used to estimate rainfall infiltration. The watershed is covered by Hydrologic Soil Groups A, B and D (Figure 5). Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. A's generally have the smallest runoff potential and D's the greatest.

Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Figure 5: Hydrologic Soil Groups



Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Table 1 shows the Subbasin areas, impervious cover and Hydrologic Soil Group areas.

Table 1: Sub-basin Areas, Impervious Cover and Hydrologic Soil Group

SHED	HSG A (AC)	HSG B (AC)	HSG D (AC)	IMP AREA	IMP %	TOTAL AREA (AC)	REMARKS
2	23.6	12.1	88.7	29.4	24%	124.5	Tennessee Hollow Creek
3	4.3	0.0	68.4	16.9	23%	72.8	
4	0.0	4.6	65.4	6.1	9%	69.9	
5	10.2	1.6	83.3	32.0	34%	95.2	

Excess runoff was transformed into flow hydrographs using the kinematic wave method. The kinematic wave method is designed principally for representing urban areas, although it can be used for undeveloped regions as well. It is a conceptual model that includes one or two representative planes. The same meteorologic boundary conditions are applied to each plane. Table 2 shows the kinematic wave parameters used for the watershed.

Table 2: Kinematic Wave Parameters for Pervious Areas

OVERLAND				
SHED	**LENGTH (FT)**	**US EL**	**DS EL**	**SLOPE**
2	300	315	309	0.0200
3	300	330	291	0.1290
4	300	355	313	0.1410
5	300	95	79	0.0530
COLLECTOR CHANNEL				
SHED	**LENGTH (FT)**	**US EL**	**DS EL**	**SLOPE**
2	617	309	220	0.0200
3	514	291	225	0.1290
4	622	313	225	0.1410
5	700	79	42	0.0530
CHANNEL				
SHED	**LENGTH (FT)**	**US EL**	**DS EL**	**SLOPE**
2	2853	220	45	0.0613
3	3352	225	45	0.0537
4	2077	225	45	0.0867
5	2290	42	17	0.0109

The overland flow length for the kinematic wave method is generally limited to less than 300 feet. The storm drains do not have the capacity to convey even the 10-year event according to Dames and Moore who performed a detailed analysis of the system in 1994 (Reference 2). A visual inspection of the results of this analysis confirms Dames and Moore's finding. Most of the flow in the 10-year event and events higher than the 10-year will be surface runoff instead of storm drain flow. The storm drain system has therefore been neglected in this study.

3.3 Results

Table 3 shows the existing 100-year flows at Doyle Drive. There are no stream gages in the watershed and the model could not be calibrated to accurately represent the area. To provide a sense of how reasonable the results may be, the watershed was analyzed using National Flood Frequency (NFF) Program regression equations for the central coast region of California. The National Flood Frequency (NFF) Program provides equations for estimating the magnitude and recurrence intervals for floods in urbanized areas throughout the conterminous United States and Hawaii. These equations have been thoroughly tested and proven to give reasonable estimates for floods having recurrence intervals between 2 and 500 years. The comparison indicates that the HEC-HMS 100-year flow is approximately 33% higher than the regression equations.

The results are greater than those presented in the Dames and Moore report entitled "Presidio of San Francisco Storm Water Management Plan" October 1994. The difference is due to the smaller shed area and short duration storm used by Dames and Moore. The Dames and Moore analysis did not include the residential area south of the Presidio.

Table 3: Tennessee Hollow Creek Flows at Doyle Drive

RECURRENCE INTERVAL (YEARS)	PEAK FLOW (CFS)		% DIFFERENCE
	HEC-HMS	REGRESSION	
2	239	146	38.9
10	484	328	32.2
25	610	405	33.6
50	716	483	32.5
100	826	557	32.6
500	1077	682	36.7

4 Hydraulic Analysis

4.1 Tennessee Hollow Creek Restoration

Parts of the Tennessee Hollow drainage system have been identified by the Presidio Trust and National Park Service (NPS) for future restoration to a natural stream and riparian corridor. A conceptual design consisting of a braided channel has been proposed for the restoration (Figure 6).

The channel restoration will allow water from San Francisco Bay to flow upstream across Mason Street and Doyle Drive. A bridge has been proposed for Mason Street but it is not known at this time whether a bridge or culverts will be constructed at Mason Street. Concurrent to previous studies for the channel restoration, this study assumes twin 10 foot by 6 foot box culverts for the crossing.

Figure 6 Tennessee Hollow Creek Restoration Proposed Braided Channel

4.2 Approach

The project site is not located in a Federal Emergency Management Agency's (FEMA) flood hazard zone. The 100-year water surface elevation was analyzed using HEC-RAS to determine freeboard and potential scour requirements. The analysis of the 100-year water surface elevation was based on two scenarios. The first scenario considered the 100-year surface runoff and the second scenario considered the 100-year tailwater. The higher of the two scenarios was adopted as the 100-year water surface for this project.

For the first scenario, the 100-year runoff discharge, determined from HEC-HMS described above, was used to analyze the water surface elevation and velocies. Water surface profile calculations require a starting water surface elevation. In general, starting water-surface elevations are based on normal depth, known water-surface elevation, rating curve or critical depth. The known water surface elevation is mean sea level at the site and it would have been the best choice but mean sea level is below the channel invert elevation. The joint probability of other known water surface elevations such as the Mean Higher High Water (MHHW) would be greater than one percent and could not be used. A rating curve would have been the next best starting water surface elevation but a rating curve was not available. A normal depth water surface elevation could not be used because the channel outlets into Crissy Marsh with a flat bottom. Critical depth starting water surface elevation was therefore used through a process of elimination.

For the second scenario, the 100-year tailwater elevation was analyzed. The 100-year tailwater elevation considered a tsunami event and extreme tides. With its location adjacent to the San Francisco Bay, the project area may potentially experience various coastal hazards such as tsunamis, extreme high tides, or sea level rise. A tsunami is a sea wave produced by an offshore earthquake, volcanic eruption, or landslide. San Francisco Bay is partially protected from inundation and damage associated with tsunamis because of the restricted hydraulic access at the Golden Gate. The 100-year tsunami wave runup was estimated by the United States Army Corps of Engineers (USACE) in a report entitled "Technical report H-75-17 Type 16 Flood Insurance Study - *Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound", Houston, J.R., Garcia, A.W., November 1975*" (Reference 3).

Extreme high tides in San Francisco Bay result from the combined effects of astronomical high tides (related to the lunar cycle) and other factors, including winds, barometric pressure, ocean temperatures, and freshwater runoff. Based on the 129-year record of daily high tide, the U.S. Army Corps of Engineers (Corps) has developed an estimated 100-year high tide elevation for various locations in the Bay (Reference 4).

Measurements from around the world indicate that the sea level is rising relative to the land surface. It is a widely held belief that the increase in global warming will continue to contribute to the rising sea levels. Based on the most recent predictions from the U.S. Environmental Protection Agency (EPA), the expected total sea level rise at the project site will be six inches by the year 2050 (Reference 5).

Table 4 shows the predicted inundation elevations associated with 100-year extreme high tide and tsunami events.

Table 4: 100-year Extreme High Tide and Tsunami Elevations

COASTAL HAZARD	ELEVATION AT PRESIDIO (FEET NAVD 1988)	SEA LEVEL RISE BY 2050 (FEET)	ELEVATION AT PRESIDIO, INCLUDING SEA LEVEL RISE (FEET NAVD 1988)
Extreme High Tide (100-year event)	8.5	0.5	9.0
Tsunami Wave Run-up (100-year event)	10.5	0.5	11.0

4.3 Water Surface Elevations and Velocities

Water surface elevations and velocities were computed in HEC-RAS for both the Tennessee Hollow Creek watershed runoff and the estimated 100-year tsunami event. The 100-year tsunami wave runup elevation is higher than the surface runoff 100-year water surface elevation. The tsunami water surface elevation is therefore adopted in this report as the controlling design 100-year water surface elevation and was used to delineate the floodplain boundaries (Figure 7). Table 5 shows the computed water surface elevations and velocities for all the events analyzed.

Table 5: Water Surface Elevations and Velocities at Doyle Drive

River Sta	Surface Runoff			100-year Tsunami	Remarks
	50-year	100-year	500-year		
	Water Surface Elevation (ft NAVD 88)				
50.4	3.6	3.9	4.3	11.0	DS Mason Street
108	5.1	5.4	6.1	9.3	US Mason Street
191	5.1	5.4	6.1	9.4	
256	5.1	5.4	6.1	9.4	DS Doyle Drive
360	5.1	5.4	6.2	9.4	
436	5.1	5.4	6.1	9.4	
511	5.2	5.5	6.2	9.4	US Doyle Drive
559	5.1	5.4	6.1	9.4	
	Velocity (fps)				
50.4	5.1	4.4	4.1	-0.8	DS Mason Street
108	2.4	2.1	1.8	-0.7	US Mason Street
191	1.5	1.4	1.3	-0.4	
256	2.1	1.9	1.6	-0.4	DS Doyle Drive
360	1.4	1.4	1.3	-0.2	
436	2.6	2.6	2.5	-0.2	
511	1.9	1.9	1.9	-0.1	US Doyle Drive
559	3.5	3.5	3.3	-0.2	

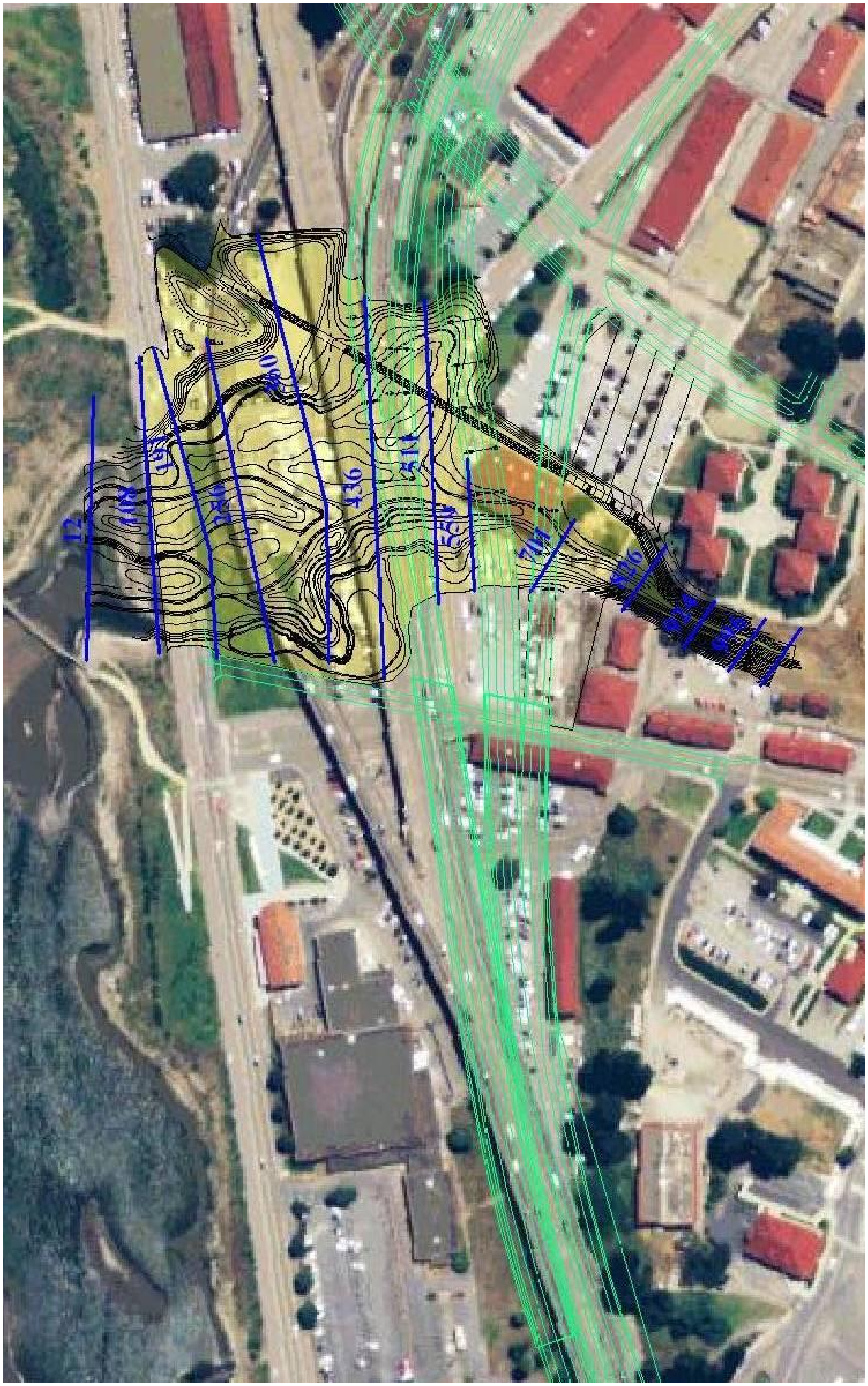
Note: Negative velocity indicates flow in the upstream direction

Table 6 shows the 50-year and 100-year freeboard. The project meets Caltrans' freeboard criterion which states that the 50-year flood must have enough freeboard to pass any anticipated drift and the 100-year flood must be able to pass the flood with no freeboard requirements and that a minimum freeboard of 0.6 meter (2 feet) is often assumed for planning studies.

Table 6: 50-year and 100-year Freeboard

Bridge	Center Line Station	Minimum Low Chord Elevation (feet NAVD 1988)	Water Surface Elevation (feet NAVD 1988)	Freeboard (ft)
50-year Freeboard				
Girard NB Ramp	49+44	13.2	5.4	7.8
Tennessee Hollow NB	53+19	10.3	5.4	4.9
Tennessee Hollow SB	52+79	10.2	5.4	4.8
Gorgas Ramp	51+16	10.0	5.4	4.6
100-year Freeboard				
Girard NB Ramp	49+44	13.2	9.4	3.8
Tennessee Hollow NB	53+19	10.3	9.4	0.9
Tennessee Hollow SB	52+79	10.2	9.4	0.8
Gorgas Ramp	51+16	10.0	9.4	0.6

Figure 7: 100-year Tsunami Floodplain Boundary



5 Scour Method and Analysis

5.1 Approach

The proposed low causeway was checked for scour at the piers. The causeway spans the proposed creek restoration without encroaching into the floodplain. As a result, no contraction or abutment scour is anticipated.

Pier scour was calculated using the Colorado State University (CSU) equation, with the water surface elevations and velocities computed in this study. The CSU equation is as follows:

$$\frac{Y_s}{a} = 2.0 K_1 K_2 K_3 \left[\frac{y_1}{a} \right]^{0.35} F^{0.43}$$

Where:

K1 correction factor for pier nose shape, Table 2, HEC 18, page 40

K2 correction factor for angle of attack of flow, Table 3, HEC 18, page 40

K3 correction factor for bed conditions, Table 1, HEC 18, page 39

a pier width, ft

y1 flow depth directly upstream from bridge, ft

F Froude number

Ys scour depth

5.2 Scour Results

The results are based on the 100-year velocities and assumed soil gradation for the bridge site. Soil gradation information is not available for the bridge site. The soil gradation for the scour analysis was assumed based on Natural Resource Service soil descriptions. The scour depths is this report are preliminary and is not to be used for because the geotechnical information required for estimation of scour depths was not available at the time of writing of this report. The analysis should be repeated to obtain a better estimate of the potential scour once the geotechnical analysis for the site is completed. The maximum pier scour is approximately 7.0 feet. The scour calculations are included in the Appendix B of this report.

6 Conclusions and Recommendations

Assuming a twin 10 foot by 6 foot culverts under Mason Street, the proposed Doyle Drive maximum low chord elevation of 18 feet will provide a freeboard of approximately 7 feet for the 50-year tsunami water surface elevation of 11.0 feet NAVD 1988 and a freeboard of approximately 10 feet over the 50-year event (Table 4).

Table 7: Hydrologic Summary

Drainage Area: 362 acres				
Frequency (Years)	Design Flood	Base Flood	Tsunami	Flood of Record
	50	100	100	N/A
Discharge (Cubic meters per second)	501	577	N/A	N/A
Water Surface (Elevation at Bridge) (feet NAVD)	8.1	8.8	11.2	N/A
Flood plain data are based upon information available when the plans were prepared and are shown to meet Federal requirements. The accuracy of said information is not warranted by the State and interested or affected parties should make their own investigation				

The anticipated 100-year scour depth at the piers is approximately 7.4 feet. It is recommended that the pier foundations be set below the scour depth.

7 References and Bibliography

[1] OSFP Information and Procedures Guide, June 20027

[2] Dames & Moore. *Presidio of San Francisco Storm Water Management Plan,* October 1994.

[3] Houston, J.R. and A.W. Garcia. *Type 16 Flood Insurance Study: Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound, Technical Report H-75-17*, November 1975

[4] United States Army Corps of Engineers, *San Francisco Bay Tidal Stage Frequency Study*, October 1984.

[5] *HEC-18 Evaluating Scour at Bridges, Resource Consultants and Engineers, National Highway Institute,* Federal Highway Administration, 6200 Georgetown Pike, Mclean, Virginia 22101.

[6] United States Environmental Protection Agency. *The Probability of Sea Level Rise*, EPA 230-R-95-008. October 1995.

[7] Manna Consultants. *Draft Technical Memorandum, Location Hydraulics Study* .November 17, 2000.

8 Appendices

Appendix A: Hydrology

ftp://ftp.wat

Rainfall Depth Duration Frequency

Station	Statio No	County	Lat	Long.	Elev.	Source	Yrs Rec	Slope	Intercep
San Francisco City	E70 7772 00	San Fr	#####	######	50	HPD	116	0.459	0.561

Maximum Rainfall For Indicated Number Of Concecutive Days

	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	1 Day	2 Day	3 Day	C-Yr
RP 2	0.16	0.23	0.28	0.37	0.50	0.71	0.85	1.20	1.59	2.11	#DIV/0!	#DIV/0!	20.84
RP 5	0.23	0.32	0.39	0.53	0.71	1.00	1.20	1.68	2.24	2.96	#DIV/0!	#DIV/0!	27.25
RP 10	0.27	0.38	0.47	0.63	0.85	1.19	1.43	2.01	2.67	3.53	#DIV/0!	#DIV/0!	30.95
RP 25	0.32	0.46	0.56	0.75	1.02	1.43	1.72	2.41	3.22	4.25	#DIV/0!	#DIV/0!	35.19
RP 50	0.36	0.52	0.63	0.85	1.14	1.61	1.94	2.71	3.61	4.77	#DIV/0!	#DIV/0!	38.09
RP 100	0.40	0.58	0.70	0.94	1.27	1.78	2.15	3.00	4.00	5.29	#DIV/0!	#DIV/0!	40.80
RP 200	0.44	0.63	0.77	1.03	1.39	1.95	2.35	3.29	4.39	5.80	#DIV/0!	#DIV/0!	43.37
RP 500	0.49	0.70	0.86	1.15	1.55	2.18	2.62	3.67	4.90	6.47	#DIV/0!	#DIV/0!	46.62
RP 1000	0.53	0.76	0.93	1.24	1.67	2.35	2.83	3.96	5.28	6.97	#DIV/0!	#DIV/0!	48.97
RP 10000	0.66	0.94	1.15	1.53	2.07	2.91	3.51	4.91	6.54	8.64	#DIV/0!	#DIV/0!	56.35

Average	0.18	0.25	0.31	0.41	0.55	0.77	0.93	1.31	1.74	2.30	#DIV/0!	#DIV/0!	21.43
Stdev	0.06	0.09	0.11	0.14	0.18	0.22	0.30	0.46	0.69	0.96	#DIV/0!	#DIV/0!	7.03
Rec Max	0.38	0.51	0.65	0.83	1.07	1.46	2.27	4.00	6.00	7.76	0.00	0.00	45.59
Rec Min	0.07	0.09	0.11	0.18	0.26	0.37	0.46	0.74	0.89	1.17	0.00	0.00	9.00
Z	2.90	2.57	2.79	2.56	2.33	2.20	3.55	**5.11**	**6.06**	**5.89**	#DIV/0!	#DIV/0!	3.35
Yrs Rec	78	78	78	78	97	98	116	116	116	116	0	0	115
Calc CV	0.343	0.356	0.363	0.350	0.325	0.290	0.326	0.350	0.397	0.420	#DIV/0!	#DIV/0!	0.328
Reg CV	.404	.404	.404	.404	.404	.404	.404	.404	.404	.404	.431	.426	.336
Skew	0.9	0.9	0.9	0.9	0.7	0.9	1.8	2.8	3.3	2.7	#DIV/0!	#DIV/0!	0.9
Reg Skew	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	0.5
Kurtosis	0.9	0.5	0.5	0.6	-0.1	0.5	4.5	12.2	16.1	11.1	#DIV/0!	#DIV/0!	1.5

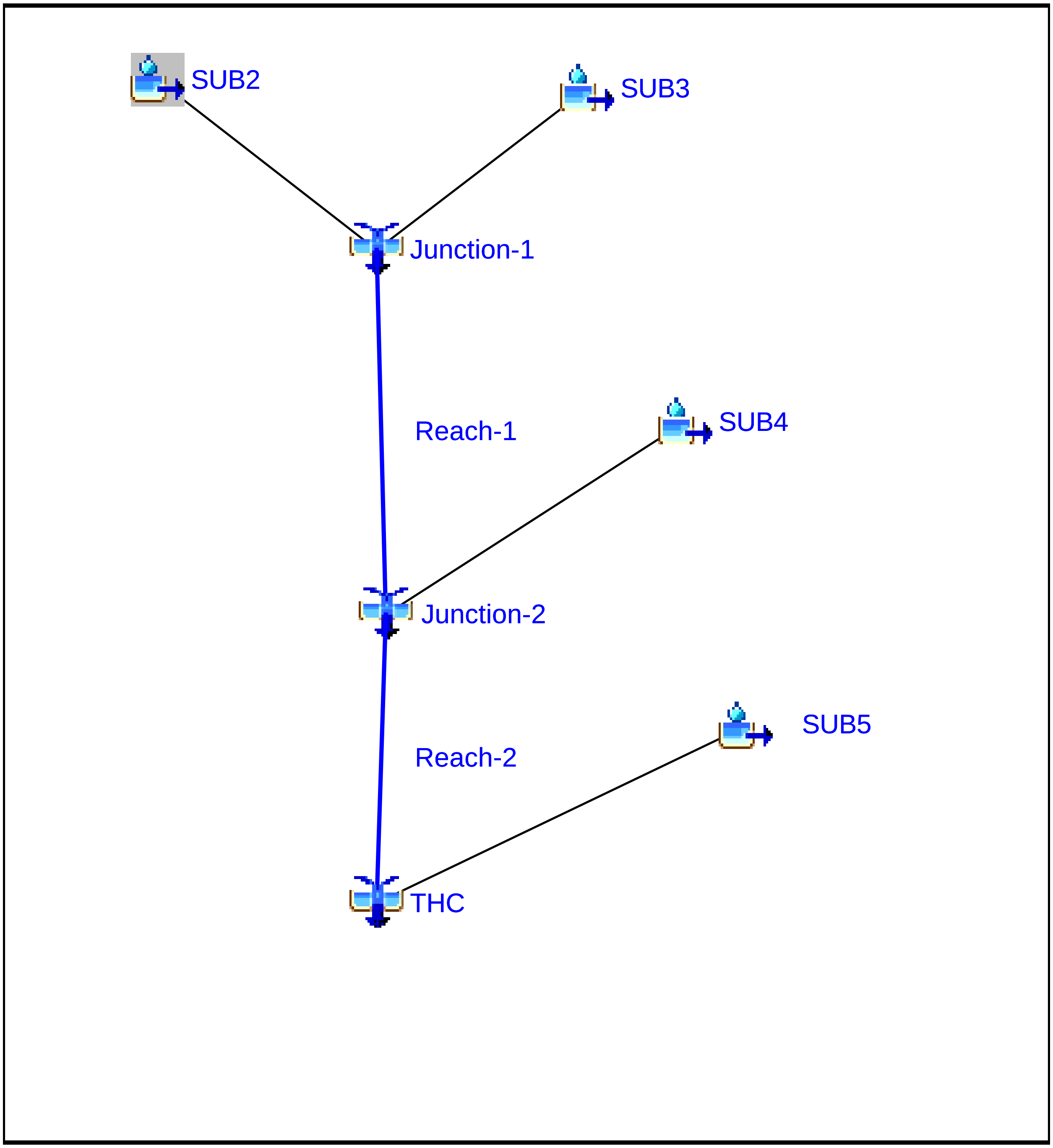
Maximum Rainfall For Indicated Number Of Concecutive Days

HEC-HMS

Project : THC

Basin Model : Basin 1

Jul 25 08:10:40 PDT 2009



Project: THC Simulation Run: 2-year

Start of Run:	15Jul2008, 00:00	Basin Model:	Basin 1
End of Run:	16Jul2008, 00:05	Meteorologic Model:	2-year
Compute Time:	25Jul2009, 08:12:55	Control Specifications:	Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Junction-1	0.3082	127.3	15Jul2008, 10:05	1.71
Junction-2	0.4175	183.7	15Jul2008, 10:05	1.76
Reach-1	0.3082	122.8	15Jul2008, 10:10	1.71
Reach-2	0.4175	179.2	15Jul2008, 10:15	1.75
SUB2	0.1945	72.8	15Jul2008, 10:05	1.73
SUB3	0.1137	54.6	15Jul2008, 10:05	1.69
SUB4	0.1093	61.2	15Jul2008, 10:05	1.89
SUB5	0.1487	61.7	15Jul2008, 10:10	1.67
THC	0.5662	238.9	15Jul2008, 10:10	1.73

Project: HMS-NEW Simulation Run: 10-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1
End of Run: 16Jul2008, 00:05 Meteorologic Model: 10-year
Compute Time: 25Jul2009, 08:31:40 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	320.9	15Jul2008, 10:05	2.92
SUB10	0.0847	73.1	15Jul2008, 10:05	2.91
SUB11	0.0554	43.8	15Jul2008, 10:05	2.73
SUB11&12	0.0928	74.0	15Jul2008, 10:05	2.68
SUB12	0.0374	31.7	15Jul2008, 10:00	2.61
SUB8	0.0699	73.2	15Jul2008, 10:00	3.11
SUB9	0.1100	101.8	15Jul2008, 10:05	3.00

Project: HMS-NEW Simulation Run: 25-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1
End of Run: 16Jul2008, 00:05 Meteorologic Model: 25-year
Compute Time: 25Jul2009, 08:31:45 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	399.2	15Jul2008, 10:00	3.53
SUB10	0.0847	91.1	15Jul2008, 10:05	3.53
SUB11	0.0554	54.9	15Jul2008, 10:05	3.30
SUB11&12	0.0928	91.9	15Jul2008, 10:05	3.24
SUB12	0.0374	40.0	15Jul2008, 10:00	3.15
SUB8	0.0699	92.5	15Jul2008, 10:00	3.76
SUB9	0.1100	128.6	15Jul2008, 10:00	3.64

Project: HMS-NEW Simulation Run: 50-year

Start of Run:	15Jul2008, 00:00	Basin Model:	Basin 1
End of Run:	16Jul2008, 00:05	Meteorologic Model:	50-year
Compute Time:	25Jul2009, 08:31:59	Control Specifications:	Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	464.1	15Jul2008, 10:00	3.98
SUB10	0.0847	104.6	15Jul2008, 10:05	3.97
SUB11	0.0554	63.1	15Jul2008, 10:05	3.71
SUB11&12	0.0928	106.1	15Jul2008, 10:00	3.65
SUB12	0.0374	46.0	15Jul2008, 10:00	3.55
SUB8	0.0699	107.2	15Jul2008, 10:00	4.23
SUB9	0.1100	149.2	15Jul2008, 10:00	4.11

Project: HMS-NEW Simulation Run: 100-year

Start of Run:	15Jul2008, 00:00	Basin Model:	Basin 1
End of Run:	16Jul2008, 00:05	Meteorologic Model:	100-year
Compute Time:	25Jul2009, 08:31:35	Control Specifications:	Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	530.3	15Jul2008, 10:00	4.43
SUB10	0.0847	118.3	15Jul2008, 10:05	4.43
SUB11	0.0554	71.2	15Jul2008, 10:05	4.13
SUB11&12	0.0928	121.3	15Jul2008, 10:00	4.06
SUB12	0.0374	52.2	15Jul2008, 10:00	3.94
SUB8	0.0699	121.9	15Jul2008, 10:00	4.70
SUB9	0.1100	171.2	15Jul2008, 10:00	4.58

Project: HMS-NEW Simulation Run: 500-year

Start of Run:	15Jul2008, 00:00	Basin Model:	Basin 1
End of Run:	16Jul2008, 00:05	Meteorologic Model:	500-yaer
Compute Time:	25Jul2009, 08:31:54	Control Specifications:	Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	684.8	15Jul2008, 10:00	5.47
SUB10	0.0847	151.9	15Jul2008, 10:00	5.47
SUB11	0.0554	89.7	15Jul2008, 10:00	5.10
SUB11&12	0.0928	156.0	15Jul2008, 10:00	5.00
SUB12	0.0374	66.3	15Jul2008, 10:00	4.84
SUB8	0.0699	154.5	15Jul2008, 10:00	5.78
SUB9	0.1100	222.4	15Jul2008, 10:00	5.67

National Flood Frequency Program
Version 3.0
Based on Water-Resources Investigations Report 02-4168
Equations from database C:\Program Files\NFF\NFFv3.2_2004-12-14.mdb
Updated by kries 9/22/2004 at 4:03:24 PM fixed decimal place in constant
Equations for California developed using English units

Site: Tennessee Hollow, California
User: touray
Date: Saturday, July 25, 2009 10:13 AM

Rural Estimate: Rural 1
Basin Drainage Area: 0.57 mi2
1 Region
Region: Central_Coast_Region
Drainage_Area = 0.57 mi2
Mean_Annual_Precipitation = 21.4 in
Altitude_Index = 0.1 thousand feet
Crippen & Bue Region 17

Urban Estimate: Urban 1
Basin Drainage Area: 0.57 mi2
1 Region
Region: National Urban
Drainage_Area = 0.57 mi2
Channel_Slope = 70 ft per mi
2-hour_2-year_Rainfall_Intensity = 0.71 in
Basin_Storage = 0 percent
Basin_Development_Factor = 12 dimensionless
Impervious_Surfaces = 23 percent
Rural Scenario = Rural 1
Crippen & Bue Region 17

Flood Peak Discharges, in cubic feet per second

Estimate	Recurrence Interval, yrs	Peak, cfs	Standard Error, %	Equivalent Years
Rural 1	2	110	150	
	5	171	110	
	10	213	96	
	25	265	96	
	50	300	110	
	100	337	120	
	500	418		
	maximum: 3510 (for C&B region 17)			
Urban 1	2	146	38	
	5	248	37	
	10	328	38	
	25	405	40	
	50	483	42	
	100	557	44	
	500	682	49	
	maximum: 3510 (for C&B region 17)			

Appendix B: Hydraulics

```
                    HEC-RAS Version 4.0.0 March 2008
                      U.S. Army Corps of Engineers
                     Hydrologic Engineering Center
                           609 Second Street
                           Davis, California

     X     X  XXXXXX    XXXX        XXXX       XX      XXXX
     X     X  X        X    X       X   X     X  X    X
     X     X  X        X            X   X    X    X   X
     XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
     X     X  X        X            X  X     X    X        X
     X     X  X        X    X       X   X    X    X        X
     X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: THC Braided Channel
Project File : THC.prj
Run Date and Time: 7/21/2009 9:39:30 AM

Project in English units

PLAN DATA

Plan Title: THC Steady
Plan File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.p01

Geometry Title: THC RESTORED CHANNEL
Geometry File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.g01

Flow Title : THC STEADY
Flow File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.f01

Plan Summary Information:

Number of:	Cross Sections =	15	Multiple Openings =	0
	Culverts =	0	Inline Structures =	0
	Bridges =	2	Lateral Structures =	0

Computational Information
- Water surface calculation tolerance = 0.01
- Critical depth calculation tolerance = 0.01
- Maximum number of iterations = 20
- Maximum difference tolerance = 0.3
- Flow tolerance factor = 0.001

Computation Options
- Critical depth computed only where necessary
- Conveyance Calculation Method: At breaks in n values only
- Friction Slope Method: Average Conveyance
- Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: THC STEADY
Flow File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.f01

Flow Data (cfs)

River	Reach	RS	2-year	10-year	25-year	50-year	100-year	500-year
THC	RESTORED	1045	239	484	610	716	826	1077

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
THC	RESTORED	2-year		Critical

GEOMETRY DATA

Geometry Title: THC RESTORED CHANNEL
Geometry File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.g01

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 1045

INPUT
Description:
Station Elevation Data num= 40

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	27.5	2.44	27.2	4.9	27.1	7.34	26.6	9.79	25.2
12.24	24.5	14.68	23.2	17.13	21.6	19.58	20.8	22.02	19.5
24.47	18.2	26.91	16.7	29.37	15.8	31.82	14.5	34.26	13.3
36.71	12.5	39.15	11.2	41.6	9.8	44.05	9	46.49	7.8
48.95	6.6	51.39	5.7	53.83	5.2	56.29	5.3	58.73	5.9
61.3	6.88	63.62	7.3	66.07	7.6	68.53	7.6	70.97	7.8
73.41	7.8	75.86	8.1	78.31	8.1	80.75	8.1	83.2	8.1
85.65	8.1	88.1	8.1	90.55	8.1	92.98	8.1	95.44	8.3

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	48.95	.025	61.3	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
48.95	61.3	47	47	47	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
66.02	95.44	23.06	F

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 996

INPUT
Description:
Station Elevation Data num= 37

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	25.6	2.45	25.3	4.9	24.8	7.35	23.7	9.8	23.2
12.25	22.8	14.7	22.2	17.16	21.5	19.6	20	22.06	18.8
24.51	18	26.96	16.5	29.41	15	31.86	14.5	34.31	12.8
36.77	11.8	39.21	10.8	41.67	9.5	44.12	8.2	46.56	7.2
49.02	6	51.47	5.5	53.92	5.1	56.37	5.6	58.83	6.1
61.28	7.2	63.72	8.2	66.17	9.2	68.62	9.7	71.08	10.1
73.53	10.1	75.98	10.4	78.44	10.5	80.89	10.4	83.33	10.4
85.78	12.5	88.23	13.4						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	46.56	.025	61.28	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
46.56	61.28	74	74	74	.1	.3

CROSS SECTION

RIVER: THC

REACH: RESTORED RS: 924

INPUT
Description:
Station Elevation Data num= 32

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	22.1	2.37	22.1	4.78	21.4	7.19	20.9	9.58	20.3
11.98	19.4	14.38	18	16.79	17	19.17	16	21.58	14.5
23.99	14	26.36	12.5	28.77	11	31.18	10.5	33.56	9
35.96	8	38.37	7.7	40.75	6.4	43.15	5.8	45.57	6.2
47.94	6.6	50.34	7.5	52.76	7.5	55.13	9.1	57.54	10.6
59.95	11.7	62.35	12.9	64.74	13.9	67.14	15	69.55	11
71.93	9.5	74.33	8.1						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	38.37	.025	50.34	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
38.37	50.34	99	99	99	.1	.3

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 826

INPUT
Description:
Station Elevation Data num= 45

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	18	2.41	18	4.84	18	7.26	17	9.67	17
12.1	17	14.53	17	16.93	17	19.36	15	21.79	10.8
24.2	9.2	26.63	7.9	29.03	7.5	31.46	4.2	33.89	4.1
36.3	4.1	38.72	4.1	41.15	4.1	43.56	4	45.99	4
48.41	4	50.82	4.3	53.25	4.7	55.68	5.2	58.09	5.6
60.51	6	62.93	6	65.35	6	67.78	6	70.19	6
72.62	6	75.05	6	77.46	6	79.89	7.1	82.31	7.1
84.72	8.2	87.15	5	89.58	5	91.98	6.8	94.41	5
96.82	5	99.25	14.2	101.68	7	104.08	12.4	106.51	17.6

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	29.03	.025	60.51	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
29.03	60.51	126	126	126	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
68.57	106.51	12.2	F

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 701

INPUT
Description:
Station Elevation Data num= 50

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	10.4	2.35	10.4	4.66	10.3	7.01	10.2	9.37	10.2
11.73	11.3	14.09	11.1	16.39	10.7	18.74	10.5	21.11	10.1
23.47	9.9	25.77	9.2	28.12	9	30.48	8.8	32.84	8.1
35.19	7.5	37.5	7.3	39.86	7.2	42.21	7.1	44.58	7
46.88	5.8	49.23	3.9	51.58	3.9	53.95	3.8	56.3	2
58.6	.5	60.97	0	63.32	0	65.68	3.4	67.98	3.1
70.34	3	72.7	3	75.05	3	77.42	3	79.72	3
82.07	3	84.43	3.2	86.79	3.4	89.09	4.2	91.44	5.3
93.81	5.4	96.16	5.4	98.52	5.3	100.83	5.8	103.18	6
105.54	6	107.89	6	110.2	6	112.55	6	114.91	6

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	53.95	.025	65.68	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
53.95	65.68	137	137	137	.1	.3

Sediment Elevation = 4

BRIDGE

RIVER: THC
REACH: RESTORED RS: 630

INPUT
Description:
Distance from Upstream XS = 10
Deck/Roadway Width = 120
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 2

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	15	11	115	15	11

Upstream Bridge Cross Section Data
Station Elevation Data num= 50

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	10.4	2.35	10.4	4.66	10.3	7.01	10.2	9.37	10.2
11.73	11.3	14.09	11.1	16.39	10.7	18.74	10.5	21.11	10.1
23.47	9.9	25.77	9.2	28.12	9	30.48	8.8	32.84	8.1
35.19	7.5	37.5	7.3	39.86	7.2	42.21	7.1	44.58	7
46.88	5.8	49.23	3.9	51.58	3.9	53.95	3.8	56.3	2
58.6	.5	60.97	0	63.32	0	65.68	3.4	67.98	3.1
70.34	3	72.7	3	75.05	3	77.42	3	79.72	3
82.07	3	84.43	3.2	86.79	3.4	89.09	4.2	91.44	5.3
93.81	5.4	96.16	5.4	98.52	5.3	100.83	5.8	103.18	6
105.54	6	107.89	6	110.2	6	112.55	6	114.91	6

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	53.95	.025	65.68	.035

Bank Sta: Left	Right	Coeff Contr.	Expan.
53.95	65.68	.1	.3

Sediment Elevation = 4

Downstream Deck/Roadway Coordinates
num= 2

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	15	11	183	15	11

Downstream Bridge Cross Section Data
Station Elevation Data num= 92

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	11	2	11	4.01	11	6.01	11	8.02	11
10.02	11	12.03	11	14.03	10.6	16.03	10	18.04	10
20.04	10	22.05	10	24.05	10	26.06	10	28.06	10
30.07	10	32.07	10	34.07	10	36.08	10	38.08	10
40.09	10	42.09	9	44.1	9	46.1	9	48.1	9
50.11	9	52.11	9	54.12	9	56.12	9	58.13	9
60.13	9	62.13	9	64.14	8.9	66.14	8	68.15	8
70.15	8	72.16	7.8	74.16	5.8	76.16	5.7	78.17	5.5
80.17	5.5	82.18	5.5	84.18	5.5	86.19	5	88.19	5
90.2	5	92.2	5	94.2	4.8	96.21	4.5	98.21	3.4
100.22	3.3	102.22	3	104.23	3	106.23	2.5	108.23	2.2
110.24	2	112.24	2	114.25	2	116.25	2	118.26	2.5
120.26	2.6	122.26	2.6	124.27	2.6	126.27	2.6	128.28	2.4
130.28	2.2	132.29	.6	134.29	0	136.29	2.4	138.3	4.02
140.3	4	142.31	4	144.31	4	146.32	5.5	148.32	5.5
150.33	5.5	152.33	5.5	154.33	5.5	156.34	5.5	158.34	5.5
160.35	5.5	162.35	5.5	164.36	5.5	166.36	5.5	168.36	5.5
170.37	5.5	172.37	5.5	174.38	5.5	176.38	5.5	178.39	5.5
180.39	5.5	182.39	5.5						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	96.21	.025	138.3	.035

Bank Sta: Left	Right	Coeff Contr.	Expan.
96.21	138.3	.1	.3

Sediment Elevation = 4

Upstream Embankment side slope = 0 horiz. to 1.0 vertical
Downstream Embankment side slope = 0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow = .98
Elevation at which weir flow begins =
Energy head used in spillway design =
Spillway height used in design =
Weir crest shape = Broad Crested

Number of Piers = 1

Pier Data
Pier Station Upstream= 75 Downstream= 142
Upstream num= 2

Width	Elev	Width	Elev
6.5	0	6.5	15

Downstream num= 2

Width	Elev	Width	Elev
6.5	0	6.5	15

Number of Bridge Coefficient Sets = 1

Low Flow Methods and Data
Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Energy Only

Additional Bridge Parameters
Add Friction component to Momentum
Do not add Weight component to Momentum
Class B flow critical depth computations use critical depth
inside the bridge at the upstream end
Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 559

INPUT
Description:
Station Elevation Data num= 92

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	11	2	11	4.01	11	6.01	11	8.02	11
10.02	11	12.03	11	14.03	10.6	16.03	10	18.04	10
20.04	10	22.05	10	24.05	10	26.06	10	28.06	10
30.07	10	32.07	10	34.07	10	36.08	10	38.08	10
40.09	10	42.09	9	44.1	9	46.1	9	48.1	9
50.11	9	52.11	9	54.12	9	56.12	9	58.13	9
60.13	9	62.13	9	64.14	8.9	66.14	8	68.15	8
70.15	8	72.16	7.8	74.16	5.8	76.16	5.7	78.17	5.5
80.17	5.5	82.18	5.5	84.18	5.5	86.19	5	88.19	5
90.2	5	92.2	5	94.2	4.8	96.21	4.5	98.21	3.4
100.22	3.3	102.22	3	104.23	3	106.23	2.5	108.23	2.2
110.24	2	112.24	2	114.25	2	116.25	2	118.26	2.5
120.26	2.6	122.26	2.6	124.27	2.6	126.27	2.6	128.28	2.4
130.28	2.2	132.29	.6	134.29	0	136.29	2.4	138.3	4.02
140.3	4	142.31	4	144.31	4	146.32	5.5	148.32	5.5
150.33	5.5	152.33	5.5	154.33	5.5	156.34	5.5	158.34	5.5
160.35	5.5	162.35	5.5	164.36	5.5	166.36	5.5	168.36	5.5
170.37	5.5	172.37	5.5	174.38	5.5	176.38	5.5	178.39	5.5
180.39	5.5	182.39	5.5						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val

0	.035	96.21	.025	138.3	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
96.21	138.3	50	50	50	.1	.3

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 511

INPUT
Description:
Station Elevation Data num= 210

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	11	2	11	4	11	6.01	11	8.01	11
10.01	11	12.01	11	14.01	11	16.02	11	18.02	11
20.02	11	22.02	11	24.02	10.5	26.03	10.1	28.03	10
30.03	10	32.03	10	34.03	10	36.04	10	38.04	10
40.04	10	42.04	10	44.04	9.9	46.04	9.7	48.05	9
50.05	9	52.05	9	54.05	9	56.05	9	58.06	9
60.06	9	62.06	9	64.06	8.8	66.06	8.3	68.07	7.5
70.07	7	72.07	7	74.07	7	76.07	5.8	78.08	5.5
80.08	5.5	82.08	5.5	84.08	5.5	86.08	5.5	88.09	5.5
90.09	5.5	92.09	5.5	94.09	5	96.09	5	98.1	5
100.1	5	102.1	5	104.1	5	106.1	5	108.11	5
110.11	4.9	112.11	4.8	114.11	3.4	116.11	3	118.12	2.8
120.12	2.8	122.12	2.4	124.12	2.4	126.12	2.1	128.12	2.1
130.13	1.9	132.13	2	134.13	2	136.13	2	138.13	2.2
140.14	2.2	142.14	2.2	144.14	2	146.14	2	148.14	2
150.15	2	152.15	2	154.15	2	156.15	2	158.15	2
160.16	1.8	162.16	1.9	164.16	2	166.16	2.4	168.16	2.5
170.17	2.6	172.17	2.6	174.17	2.6	176.17	2.7	178.17	2.8
180.18	3	182.18	3	184.18	3	186.18	3	188.18	4
190.19	4	192.19	4	194.19	4	196.19	4	198.19	4
200.2	4	202.2	3.8	204.2	3.4	206.2	2.8	208.2	2.7
210.2	2.6	212.21	2.7	214.21	2.6	216.21	2.7	218.21	2.6
220.21	2.6	222.22	2.6	224.22	2.6	226.22	2.6	228.22	2.6
230.22	2.6	232.23	2.5	234.23	3.2	236.23	4	238.23	4
240.23	4	242.24	4	244.24	4	246.24	4	248.24	4
250.24	4	252.25	4	254.25	4	256.25	4	258.25	4
260.25	4.6	262.26	5	264.26	5	266.26	5	268.26	5
270.26	5	272.27	5	274.27	5	276.27	2.5	278.27	1
280.27	0	282.28	0	284.28	0	286.28	0	288.28	0
290.28	0	292.28	.8	294.29	2	296.29	4	298.29	4
300.29	4	302.29	4	304.3	4	306.3	4	308.3	4
310.3	4	312.3	4	314.31	4	316.31	5	318.31	5
320.31	5	322.31	5	324.32	5	326.32	5	328.32	5
330.32	5	332.32	5	334.33	5	336.33	5	338.33	5
340.33	5	342.33	5	344.34	5	346.34	5	348.34	5
350.34	5	352.34	5	354.35	4.4	356.35	4	358.35	4
360.35	4	362.35	4	364.36	3	366.36	2.5	368.36	2.6
370.36	2.6	372.36	2.7	374.36	2.9	376.37	3.3	378.37	4.8
380.37	5.1	382.37	5.3	384.37	5.5	386.38	5.8	388.38	6
390.38	6	392.38	6	394.38	6.5	396.39	7.1	398.39	7.4
400.39	7.7	402.39	8.4	404.39	8.6	406.4	9.5	408.4	9.8
410.4	10	412.4	10	414.4	10	416.41	10	418.41	10

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	112.11	.025	188.18	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
112.11	188.18	96	96	96	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
199.4	418.41	8	F

Sediment Elevation = 4

CROSS SECTION

RIVER: THC

REACH: RESTORED RS: 436

INPUT
Description:
Station Elevation Data num= 264

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	9	2	9	4.01	9	6.01	9	8.01	9
10.01	8.6	12.02	7.5	14.02	7.4	16.02	7	18.02	7
20.03	7	22.03	7	24.03	7	26.03	7	28.04	7
30.04	7	32.04	7	34.04	7	36.05	7	38.05	7
40.05	7	42.05	7	44.06	7	46.06	7	48.06	7
50.07	7	52.07	7	54.07	7	56.07	7	58.08	7
60.08	7	62.08	7	64.08	7	66.09	7	68.09	7
70.09	7	72.09	7	74.1	7	76.1	7	78.1	7
80.1	7	82.11	7	84.11	7	86.11	7	88.11	7
90.12	7	92.12	7	94.12	7	96.13	7	98.13	7
100.13	7	102.13	7	104.14	7	106.14	7	108.14	7
110.14	7	112.15	7	114.15	7	116.15	7	118.15	7
120.16	7	122.16	7	124.16	7	126.16	7	128.17	7.4
130.17	7.5	132.17	7.5	134.17	7.5	136.18	7.5	138.18	7.5
140.18	7.5	142.19	7.5	144.19	7.5	146.19	7.5	148.19	7.5
150.2	7.5	152.2	7.5	154.2	7.5	156.2	7.5	158.21	7.5
160.21	7.5	162.21	7.5	164.21	7.5	166.22	7.5	168.22	7.5
170.22	8	172.22	7.4	174.23	6.3	176.23	5.5	178.23	5.5
180.24	5.5	182.24	5.5	184.24	5.5	186.24	5	188.25	5
190.25	5	192.25	5	194.25	5	196.26	5	198.26	5
200.26	4.5	202.26	3.7	204.27	3.2	206.27	3	208.27	2.1
210.27	2	212.28	2	214.28	2	216.28	1.8	218.28	2.1
220.29	4	222.29	4	224.29	4	226.3	4	228.3	4
230.3	3	232.3	2.9	234.31	2.8	236.31	2.3	238.31	2.2
240.31	2	242.32	2.2	244.32	2.1	246.32	2	248.32	2
250.33	2.1	252.33	1.8	254.33	2.1	256.33	2.1	258.34	2.1
260.34	2.1	262.34	1.8	264.34	1.8	266.35	0	268.35	0
270.35	4.5	272.36	4.5	274.36	5	276.36	5	278.36	5
280.37	5	282.37	5	284.37	5	286.37	5	288.38	5
290.38	5	292.38	5	294.38	5	296.39	3.9	298.39	2.1
300.39	2.1	302.39	2.1	304.4	2.1	306.4	1.8	308.4	2.1
310.4	2.1	312.41	1.8	314.41	1.8	316.41	4	318.42	4
320.42	4	322.42	4	324.42	0	326.43	0	328.43	0
330.43	0	332.43	0	334.44	0	336.44	4	338.44	4
340.44	4	342.45	4	344.45	4	346.45	4	348.45	5
350.46	5	352.46	5	354.46	5	356.46	5	358.47	5
360.47	5	362.47	5	364.48	5	366.48	5	368.48	5
370.48	5	372.49	5	374.49	4.5	376.49	4.5	378.49	2
380.5	0	382.5	0	384.5	4	386.5	3.6	388.51	4
390.51	4	392.51	4	394.51	4	396.52	4	398.52	4
400.52	4	402.52	4	404.53	3.4	406.53	2.5	408.53	2.6
410.54	2.6	412.54	2.6	414.54	2.6	416.54	2.7	418.55	2.7
420.55	2.8	422.55	2.4	424.55	1.2	426.56	1.2	428.56	1.6
430.56	2.4	432.56	2.8	434.57	3.6	436.57	.8	438.57	0
440.57	0	442.58	1.1	444.58	4.4	446.58	3.3	448.58	2.7
450.59	2.8	452.59	3.9	454.59	6	456.6	6	458.6	6
460.6	6	462.6	6	464.61	6	466.61	6	468.61	6
470.61	7	472.62	7	474.62	7	476.62	7	478.62	7
480.63	7	482.63	7	484.63	7.3	486.63	7.7	488.64	8.6
490.64	8.6	492.64	8.5	494.65	.9	496.65	0	498.65	4.5
500.65	0	502.66	0	504.66	0	506.66	4.5	508.66	8.1
510.67	9	512.67	9.9	514.67	10	516.67	10	518.68	10
520.68	10	522.68	10	524.68	10	526.69	10		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	228.3	.025	270.35	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
228.3	270.35	73	73	73	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
290.71	526.69	6.97	F

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 360

INPUT
Description:
Station Elevation Data num= 295

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	7	2	7	4	7.5	6	8	8	7.4
10	5.8	12	5.5	14	5.5	16	5.5	18	5
20	5	22	5	24	5	26	4	28	4
30.01	4	32.01	3	34.01	3	36.01	3	38.01	3
40.01	2	42.01	2	44.01	2	46.01	2	48.01	2
50.01	2	52.01	2	54.01	2	56.01	2	58.01	2.2
60.01	2.5	62.01	3	64.01	3.2	66.01	3.2	68.01	3.9
70.01	4.4	72.01	4.8	74.01	4.9	76.01	5	78.01	5
80.01	5	82.01	5	84.01	5	86.02	5	88.02	5.5
90.02	5.5	92.02	5.5	94.02	5.5	96.02	5.5	98.02	7
100.02	7	102.02	7	104.02	7	106.02	7	108.02	7
110.02	7	112.02	7	114.02	7	116.02	5.5	118.02	5.5
120.02	5.5	122.02	5.5	124.02	5	126.02	5	128.02	5
130.02	4.5	132.02	4	134.02	3.8	136.02	3	138.02	2.7
140.02	2.1	142.03	2	144.03	2	146.03	1.9	148.03	2.1
150.03	1.8	152.03	4	154.03	4.3	156.03	5	158.03	5
160.03	5	162.03	5	164.03	5	166.03	5	168.03	5
170.03	5	172.03	5	174.03	5	176.03	4	178.03	4
180.03	3.3	182.03	2.1	184.03	2	186.03	1.7	188.03	1.4
190.03	1.2	192.03	1.1	194.03	1	196.03	1	198.04	1
200.04	1	202.04	1	204.04	1	206.04	1	208.04	1
210.04	1	212.04	1	214.04	1	214.51	1	216.57	1.3
218.63	1.3	220.69	1.6	222.76	1.6	224.82	2	226.88	1.9
228.95	1.9	231.01	1.9	233.07	1.9	235.13	1.9	237.2	2.3
239.26	5	241.32	5	243.39	5	245.45	5	247.51	5
249.58	5	251.64	5	253.7	5	255.76	5	257.83	5
259.89	5	261.95	5	264.02	5	266.08	5	268.14	5
270.2	5	272.27	5	274.33	5	276.39	5	278.46	5
280.52	5	282.58	5	284.64	5	286.71	5	288.77	2.3
290.83	1.8	292.9	1.8	294.96	2.1	297.02	1.8	299.08	1.8
301.15	1.8	303.21	2.1	305.27	1.8	307.34	2.1	309.4	2.1
311.46	2.1	313.52	5	315.59	5	317.65	5	319.71	5
321.78	5	323.84	5	325.9	5	327.96	5	330.03	5
332.09	5	334.15	5	336.22	5	338.28	5	340.34	5
342.4	5	344.47	5	346.53	2	348.59	2	350.66	2
352.72	2	354.78	2	356.84	2	358.91	2	360.97	3
363.03	3.6	365.1	4	367.16	5.5	369.22	5.5	371.28	6
373.35	6.7	375.41	7	377.47	7	379.54	7	381.6	7
383.66	6	385.72	6	387.79	6	389.85	6	391.91	6
393.98	6	396.04	5	398.1	5	400.16	5	402.23	5
404.29	5	406.35	5	408.42	5	410.48	5	412.54	5
414.6	5	416.67	5	418.73	5	420.79	5	422.86	5
424.92	5	426.98	5	429.04	5	431.11	5	433.17	5
435.23	5	437.3	5	439.36	5	441.42	5	443.49	5
445.55	5	447.61	5	449.67	5	451.74	5	453.8	5
455.86	5	457.93	5	459.99	5	462.05	5	464.11	5
466.18	5	468.24	5	470.3	5	472.37	5	474.43	5
476.49	5	478.55	5	480.62	3	482.68	2	484.74	1
486.81	1.5	488.87	1.5	490.93	1.5	492.99	0	495.06	1
497.12	.5	499.18	0	501.25	0	503.31	0	505.37	0
507.43	0	509.5	0	511.56	0	513.62	0	515.69	.5
517.75	1	519.81	2	521.87	2	523.94	2.5	526	3.5
528.06	5.2	530.13	5.2	532.19	5.1	534.25	5	536.31	5
538.38	5	540.44	5	542.5	5	544.57	5	546.63	5
548.69	5	550.75	5	552.82	5	554.88	5	556.94	5
559.01	5	561.07	5	563.13	5	565.19	5	567.26	5
569.32	5	571.38	5	573.45	5	575.51	5	577.57	5.1
579.63	5.1	581.7	5.3	583.76	5.8	585.82	6.9	587.89	7.1
589.95	7.6	592.01	8.3	594.07	8.3	596.14	8.5	598.2	8.5

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	174.03	.025	239.26	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
174.03	239.26	140	140	140	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
263.48	598.2	7.37	F

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 256

INPUT
Description:
Station Elevation Data num= 224

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	8	2.04	8	4.09	8	6.13	7.6	8.17	7.6
10.22	7.5	12.26	7.2	14.3	6.6	16.35	6.5	18.39	6.1
20.43	6	22.48	6	24.52	6	26.56	6	28.61	6
30.65	6	32.69	6	34.74	6	36.78	6	38.82	6
40.87	6	42.91	6	44.95	6	47	6	49.04	6
51.08	6.1	53.13	7	55.17	7	57.21	7	59.26	6.9
61.3	5.5	63.34	5	65.39	5	67.43	4.4	69.47	3.5
71.52	3	73.56	2.6	75.6	2.6	77.65	2.3	79.69	2
81.73	1.8	83.78	2	85.82	2.8	87.86	4	89.91	4
91.95	4	93.99	4	96.04	4	98.08	2.2	100.12	2.1
102.17	1.7	104.21	1.4	106.25	1.4	108.3	1	110.34	1
112.38	1	114.43	1	116.47	1	118.51	1	120.56	1
122.6	1	124.64	1.4	126.69	3.4	128.73	5	130.77	5
132.82	5	134.86	5	136.9	5	138.95	5	140.99	5
143.03	5	145.08	5	147.12	5	149.16	5	151.21	5
153.25	5	155.29	5	157.34	5	159.38	5	161.42	5
163.47	5	165.51	5	167.55	5	169.6	5	171.64	5
173.68	5	175.73	5	177.77	5	179.81	5	181.86	5
183.9	5	185.95	5	187.99	5	190.03	5	192.08	5
194.12	5	196.16	2.2	198.21	2.3	200.25	2.4	202.29	2.7
204.34	3	206.38	3.4	208.42	4.5	210.47	4.7	212.51	5
214.55	5	216.6	5	218.64	5	220.68	5	222.73	5
224.77	5	226.81	5	228.86	5	230.9	5	232.94	5
234.99	5	237.03	5	239.07	5	241.12	5	243.16	4
245.2	4	247.25	4	249.29	4	251.33	4	253.38	3
255.42	3	257.46	2.8	259.51	2.6	261.55	1.8	263.59	1.4
265.64	1.3	267.68	1	269.72	1	271.77	1	273.81	1
275.85	1	277.9	1	279.94	1	281.98	3.8	284.03	5
286.07	5	288.11	5	290.16	5	292.2	5	294.24	5
296.29	5	298.33	5	300.37	5	302.42	5	304.46	5
306.5	5	308.55	5	310.59	2	312.63	2	314.68	2
316.72	2	318.76	2	320.81	2	322.85	2	324.89	2.3
326.94	2.6	328.98	3.5	331.02	3.6	333.07	3.6	335.11	3.5
337.15	3.4	339.2	3.4	341.24	3.5	343.28	3.8	345.33	5.1
347.37	5.5	349.41	5.5	351.46	5.5	353.5	5.5	355.54	5.5
357.59	5.8	359.63	6.1	361.67	6.3	363.72	6.6	365.76	6.9
367.8	6	369.85	5.6	371.89	5.4	373.93	5.3	375.98	5.3
378.02	5.2	380.06	5.2	382.11	5.1	384.15	5	386.19	5
388.24	5	390.28	5	392.32	5	394.37	5	396.41	5
398.45	5	400.5	5	402.54	5	404.58	5	406.63	5
408.67	5	410.71	5	412.76	5	414.8	5.7	416.84	6
418.89	7	420.93	7	422.97	7.1	425.02	8.3	427.06	8.6
429.1	9.4	431.15	9.9	433.19	10.5	435.23	11	437.28	11
439.32	11	441.36	17.5	443.41	24	445.45	24	447.49	24
449.54	24	451.58	24	453.62	19.2	455.67	24		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	251.33	.025	286.07	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
251.33	286.07	60	60	60	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
295.35	455.67	8.84	F

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 191

INPUT
Description:
Station Elevation Data num= 214

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	10	2	10	4.01	10	6.01	10	8.02	10
10.02	10	12.02	10	14.03	10	16.03	8	18.04	8
20.04	8	22.05	7.6	24.05	7	26.05	7	28.06	5.5
30.06	5.5	32.07	5	34.07	5	36.07	5	38.08	5
40.08	5	42.09	5	44.09	4	46.09	4	48.1	4
50.1	4	52.11	4	54.11	4	56.12	4	58.12	4
60.12	4	62.13	3	64.13	3	66.14	3	68.14	3
70.14	3	72.15	3	74.15	3	76.16	3	78.16	3
80.16	1.3	82.17	1	84.17	1	86.18	1	88.18	1
90.19	1	92.19	1	94.19	1	96.2	1	98.2	1
100.21	2	102.21	2	104.21	3	106.22	2.1	108.22	2
110.23	1.5	112.23	1.5	114.23	1.1	116.24	1.2	118.24	1.3
120.25	1.2	122.25	1.2	124.26	1.1	126.26	2.6	128.26	5
130.27	5	132.27	5	134.28	5	136.28	5	138.28	5
140.29	5	142.29	5	144.3	5	146.3	5	146.87	5
148.94	5	151.02	5	153.1	5	155.17	5	157.25	2
159.33	2	161.4	2	163.48	2	165.56	2	167.63	2.1
169.71	3	171.79	3	173.86	3	175.94	3.7	178.02	4
180.09	4	182.17	4.2	184.25	5	186.32	5	188.4	5
190.48	5	192.55	5	194.63	5	196.71	5	198.78	5
200.86	5	202.94	5	205.01	5	207.09	5	209.17	5
211.24	5	213.32	5	215.4	4.8	217.47	4.8	219.55	3.3
221.63	3.2	223.7	3.2	225.78	2.8	227.86	2.5	229.93	2.2
232.01	1.7	234.09	1.5	236.16	1.3	238.24	1	240.32	1
242.39	1	244.47	1	246.55	1	248.62	1	250.7	1
252.78	1.1	254.85	2.2	256.93	5	259.01	5	261.08	5
263.16	5	265.24	5	267.31	5	269.39	5	271.47	5
273.54	5	275.62	5	277.7	5	279.77	5	281.85	5
283.93	5	286	5	288.08	3.8	290.16	2	292.23	2
294.31	2	296.39	2	298.46	2.1	300.54	3	302.62	3.3
304.69	4	306.77	4	308.85	4	310.92	5.5	313	5.5
315.08	5.5	317.15	6.3	319.23	6.9	321.31	6.7	323.38	6.4
325.46	6	327.54	6	329.61	6.2	331.69	6.9	333.77	7.1
335.84	7.2	337.92	7.4	340	8.5	342.07	9	344.15	9
346.23	9.2	348.3	10.2	350.38	10.5	352.46	10.6	354.53	10.7
356.61	10.7	358.69	10.9	360.76	11	362.84	11	364.92	11
366.99	11	369.07	11	371.15	11	373.22	11	375.3	11
377.38	11	379.45	11	381.53	11	383.61	11	385.68	11
387.76	11	389.84	11	391.91	11	393.99	11	396.07	11
398.14	11	400.22	11	402.3	11	404.37	11	406.45	11
408.53	11	410.6	11	412.68	11	414.76	11	416.83	11
418.91	11	420.99	11	423.06	11	425.14	11	427.22	11
429.29	11	431.37	11	433.45	11	435.52	11		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	217.47	.025	259.01	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
217.47	259.01	63	63	63	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
263.96	435.52	6.73	F

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 108

INPUT
Description:
Station Elevation Data num= 205

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	10	2	10	4.01	10	6.01	10	8.02	10
10.02	8	12.03	8	14.03	8	16.03	8	18.04	8

20.04	8	22.05	8	24.05	7	26.06	7	28.06	5.5
30.07	5.5	32.07	5	34.07	5	36.08	5	38.08	4.1
40.09	4	42.09	4	44.1	4	46.1	4	48.1	3.8
50.11	2.8	52.11	2.8	54.12	2.8	56.12	2.4	58.13	2.4
60.13	2.1	62.13	2.1	64.14	2.1	66.14	1.7	68.15	1.4
70.15	2.1	72.16	2.1	74.16	2.1	76.16	2.5	78.17	2.6
80.17	3.2	82.18	3.4	84.18	4.6	86.19	4.8	88.19	5
90.2	5	92.2	5	94.2	5	96.21	5	98.21	5
100.22	5	102.22	5	104.23	5	106.23	5	108.23	5
110.24	5	112.24	5	114.25	4.4	116.25	4	118.26	4
120.26	3.9	122.26	3	124.27	3	126.27	2.6	128.28	1.5
130.28	1	132.29	1.4	134.29	2.3	136.29	3	138.3	3
140.3	3	142.31	3	144.31	4	146.32	4	148.32	4
150.33	4	152.33	4	154.33	4	156.34	4	158.34	4
160.35	5	162.35	5	164.36	5	166.36	5	168.36	5
170.37	5	172.37	5	174.38	5	176.38	5	178.39	5
180.39	5	182.39	5	184.4	4.3	186.4	4	188.41	4
190.41	4	192.42	4	194.42	4	196.43	4	198.43	4
200.43	3	202.44	3	204.44	3	206.45	3	208.45	3
210.46	3	212.46	1.7	214.46	1	216.47	1	218.47	1
220.48	1	222.48	1	224.49	1	226.49	1.4	228.49	1.8
230.5	3	232.5	3	234.51	3	236.51	3	238.52	3
240.52	4	242.52	4	244.53	4	246.53	4	248.54	4
250.54	4	252.55	4	254.55	4	256.56	4	258.56	5.5
260.56	5.5	262.57	5.5	264.57	5.5	266.58	5.5	268.58	5.5
270.59	6	272.59	6	274.59	6	276.6	7	278.6	7
280.61	7	282.61	7	284.62	7.8	286.62	8.2	288.62	8.4
290.63	8.6	292.63	9.4	294.64	9.9	296.64	10	298.65	10
300.65	10	302.66	10.7	304.66	11	306.66	11	308.67	11
310.67	11	312.68	11	314.68	11	316.69	11	318.69	11
320.69	11	322.7	11	324.7	11	326.71	11	328.71	11
330.72	11	332.72	11	334.72	11	336.73	11	338.73	11
340.74	11	342.74	11	344.75	11	346.75	11	348.75	11
350.76	11	352.76	11	354.77	11	356.77	11	358.78	11
360.78	11	362.79	11	364.79	11	366.79	11	368.8	11
370.8	11	372.81	11	374.81	11	376.82	11	378.82	11
380.82	11	382.83	11	384.83	11	386.84	11	388.84	11
390.85	11	392.85	11	394.85	11	396.86	11	398.86	11
400.87	11	402.87	11	404.88	11	406.88	11	408.88	11

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	210.46	.025	230.5	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
210.46	230.5	48.6	48.6	48.6	.1	.3

Sediment Elevation = 4

BRIDGE

RIVER: THC
REACH: RESTORED RS: 90

INPUT
Description:
Distance from Upstream XS = 18
Deck/Roadway Width = 20
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 2

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	12	10	300	12	10

Upstream Bridge Cross Section Data
Station Elevation Data num= 205

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	10	2	10	4.01	10	6.01	10	8.02	10
10.02	8	12.03	8	14.03	8	16.03	8	18.04	8
20.04	8	22.05	8	24.05	7	26.06	7	28.06	5.5
30.07	5.5	32.07	5	34.07	5	36.08	5	38.08	4.1
40.09	4	42.09	4	44.1	4	46.1	4	48.1	3.8
50.11	2.8	52.11	2.8	54.12	2.8	56.12	2.4	58.13	2.4
60.13	2.1	62.13	2.1	64.14	2.1	66.14	1.7	68.15	1.4

70.15	2.1	72.16	2.1	74.16	2.1	76.16	2.5	78.17	2.6
80.17	3.2	82.18	3.4	84.18	4.6	86.19	4.8	88.19	5
90.2	5	92.2	5	94.2	5	96.21	5	98.21	5
100.22	5	102.22	5	104.23	5	106.23	5	108.23	5
110.24	5	112.24	5	114.25	4.4	116.25	4	118.26	4
120.26	3.9	122.26	3	124.27	3	126.27	2.6	128.28	1.5
130.28	1	132.29	1.4	134.29	2.3	136.29	3	138.3	3
140.3	3	142.31	3	144.31	4	146.32	4	148.32	4
150.33	4	152.33	4	154.33	4	156.34	4	158.34	4
160.35	5	162.35	5	164.36	5	166.36	5	168.36	5
170.37	5	172.37	5	174.38	5	176.38	5	178.39	5
180.39	5	182.39	5	184.4	4.3	186.4	4	188.41	4
190.41	4	192.42	4	194.42	4	196.43	4	198.43	4
200.43	3	202.44	3	204.44	3	206.45	3	208.45	3
210.46	3	212.46	1.7	214.46	1	216.47	1	218.47	1
220.48	1	222.48	1	224.49	1	226.49	1.4	228.49	1.8
230.5	3	232.5	3	234.51	3	236.51	3	238.52	3
240.52	4	242.52	4	244.53	4	246.53	4	248.54	4
250.54	4	252.55	4	254.55	4	256.56	4	258.56	5.5
260.56	5.5	262.57	5.5	264.57	5.5	266.58	5.5	268.58	5.5
270.59	6	272.59	6	274.59	6	276.6	7	278.6	7
280.61	7	282.61	7	284.62	7.8	286.62	8.2	288.62	8.4
290.63	8.6	292.63	9.4	294.64	9.9	296.64	10	298.65	10
300.65	10	302.66	10.7	304.66	11	306.66	11	308.67	11
310.67	11	312.68	11	314.68	11	316.69	11	318.69	11
320.69	11	322.7	11	324.7	11	326.71	11	328.71	11
330.72	11	332.72	11	334.72	11	336.73	11	338.73	11
340.74	11	342.74	11	344.75	11	346.75	11	348.75	11
350.76	11	352.76	11	354.77	11	356.77	11	358.78	11
360.78	11	362.79	11	364.79	11	366.79	11	368.8	11
370.8	11	372.81	11	374.81	11	376.82	11	378.82	11
380.82	11	382.83	11	384.83	11	386.84	11	388.84	11
390.85	11	392.85	11	394.85	11	396.86	11	398.86	11
400.87	11	402.87	11	404.88	11	406.88	11	408.88	11

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	210.46	.025	230.5	.035

Bank Sta: Left	Right	Coeff Contr.	Expan.
210.46	230.5	.1	.3

Sediment Elevation = 4

Downstream Deck/Roadway Coordinates
num= 2

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
0	12	10	350	12	10

Downstream Bridge Cross Section Data
Station Elevation Data num= 377

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5.92	1.94	5.92	2.04	5.92	3.89	5.92	4.08	5.92
5.83	5.82	6.12	5.8	7.78	5.8	8.17	5.64	9.72	5
10.21	5	11.67	5	12.25	5	13.61	5	14.29	5
15.55	5	16.33	5	17.51	5	18.38	5	19.45	5
20.43	5	21.4	5	22.47	4.78	23.34	4.6	24.51	4.6
25.29	4.6	26.55	4.21	27.23	4	28.59	4	29.18	4
30.63	3.85	31.12	3.8	32.68	3.8	33.06	3.8	34.72	3.8
35.01	3.8	36.76	3.48	36.95	3.44	38.8	3.4	38.9	3.4
40.84	3.4	42.79	3.4	42.88	3.4	44.73	3.4	44.93	3.39
46.67	3.32	46.97	3.26	48.62	2.92	49.01	2.92	50.56	2.92
51.05	2.92	52.52	2.92	53.1	2.87	54.46	2.76	55.14	2.76
56.41	2.76	57.18	2.71	58.35	2.64	59.23	2.64	60.29	2.64
61.27	2.64	62.24	2.64	63.31	2.55	64.18	2.48	65.35	2.41
66.13	2.36	67.39	2.54	68.07	2.64	69.43	2.64	70.02	2.64
71.48	2.64	71.96	2.64	73.52	2.77	73.9	2.77	75.56	2.65
75.85	2.58	77.6	2.34	77.79	2.34	79.64	2.2	79.74	2.2
81.68	2.62	83.63	2.7	83.73	2.7	85.58	2.67	85.77	2.66
87.53	2.82	87.81	2.84	89.47	2.89	89.86	2.9	91.41	2.9
91.9	2.9	93.36	3.33	93.94	3.5	95.3	3.62	95.99	3.68
97.25	3.75	98.03	3.8	99.19	4	100.07	4.16	101.14	4.29
102.11	4.4	103.08	4.4	104.15	4.4	105.02	4.4	106.19	4.4
106.97	4.4	108.23	4.4	108.91	4.4	110.28	4.23	110.86	4.16
112.32	4.04	112.8	4	114.36	4	114.75	4	116.4	3.97

116.69	3.96	118.44	3.64	118.64	3.6	120.48	3.6	120.59	3.6
122.53	3.44	124.48	3	124.58	2.99	126.42	2.8	126.62	2.82
128.37	2.96	128.66	3.01	130.31	3.32	130.7	3.38	132.25	3.6
132.74	3.6	134.2	3.6	134.79	3.6	136.14	3.6	136.83	3.6
138.09	3.6	138.87	3.76	140.03	4	140.91	4	141.98	4
142.95	4	143.92	4	144.99	4	145.87	4	147.04	4
147.81	4	149.08	4	149.75	4	151.12	4	151.7	4
153.16	4	153.65	4	155.2	4.32	155.6	4.4	157.24	4.4
157.54	4.38	159.29	4.28	159.49	4.23	161.34	3.8	161.43	3.79
163.37	3.68	165.32	3.57	165.42	3.56	167.26	2.91	167.46	2.84
169.21	2.74	169.5	2.72	171.15	3.01	171.54	3.08	173.1	3.49
173.59	3.62	175.04	3.75	175.63	3.8	176.98	3.8	177.67	3.7
178.93	3.52	179.71	3.47	180.87	3.4	181.75	3.4	182.82	3.71
183.79	4	184.76	4	185.84	4	186.71	4	187.88	4
188.66	4	189.92	4	190.61	4	191.96	4	192.55	4
194	3.7	194.49	3.6	196.05	3.6	196.44	3.6	198.1	3.6
198.38	3.6	200.14	3.6	200.33	3.6	202.18	3.6	202.27	3.6
204.22	3.6	205.6	2.88	206.98	2.77	208.35	2.53	209.73	2.12
210.42	1.82	211.11	1.55	212.49	1.37	213.86	1.24	215.24	1.12
216.62	1	217.66	1	218.7	1	219.75	1	220.79	1
221.83	1	223.25	1.16	224.67	1.27	226.09	1.37	227.03	1.48
227.51	1.53	228.93	1.94	230.35	2.34	231.77	2.45	232.22	2.56
233.19	2.85	234.61	3.1	236.02	3.35	237.44	3.54	239.05	3.58
239.83	3.6	240.66	3.6	242.22	3.6	242.27	3.6	243.89	3.68
244.61	3.9	245.5	4.25	247	4.48	247.1	4.49	248.72	4.57
249.39	4.6	250.33	4.6	251.78	4.6	251.94	4.63	253.55	4.96
254.16	5.08	255.16	5.13	256.55	5.2	256.77	5.2	258.39	5.2
258.95	5.41	259.99	5.8	261.34	5.8	261.6	5.8	263.22	5.8
263.73	5.8	264.83	5.8	266.12	5.8	266.44	5.8	268.05	5.8
268.51	5.86	269.66	6	270.9	6	271.27	6	272.88	6
273.29	6.1	274.49	6.4	275.68	6.4	276.1	6.4	277.72	6.4
278.07	6.4	279.32	6.4	280.45	6.62	280.94	6.72	282.55	6.88
282.84	6.89	284.15	6.96	285.23	7.01	285.77	7.04	287.38	7.36
287.62	7.39	288.99	7.56	290.01	7.59	290.6	7.6	292.22	7.6
292.4	7.6	293.82	7.6	294.79	7.77	295.44	7.88	297.05	8
297.18	8	298.65	8	299.57	8	300.27	8	301.88	8
301.97	8	303.49	8	304.36	8	305.1	8	306.72	8
306.74	8	308.32	8	309.13	8	309.93	8.02	311.52	8.06
311.55	8.06	313.15	8.06	313.91	8.06	314.77	8.06	316.3	8.06
316.38	8.06	317.99	8.06	318.69	8.06	319.6	8.11	321.08	8.18
321.21	8.19	322.82	8.27	323.47	8.3	324.43	8.37	325.86	8.48
326.05	8.49	327.65	8.62	328.24	8.66	329.27	8.66	330.63	8.66
330.88	8.7	332.48	8.99	333.02	9.08	334.1	9.3	335.41	9.56
335.71	9.62	337.32	9.94	337.8	10.04	338.93	10.1	340.19	10.16
340.54	10.16	342.15	10.16	342.59	10.16	343.77	10.19	344.98	10.22
345.38	10.22	346.98	10.22	347.37	10.22	348.6	10.22	349.76	10.22
350.21	10.23	351.82	10.27	352.15	10.28	353.43	10.38	354.53	10.46
355.04	10.49	356.65	10.57	356.92	10.58	358.26	10.61	359.31	10.64
359.87	10.64	361.48	10.64	361.7	10.64	363.1	10.68	364.09	10.7
364.71	10.72	366.32	10.76	366.48	10.76	367.93	10.8	368.87	10.82
369.54	10.82	371.15	10.82	371.26	10.82	372.76	10.86	373.65	10.88
374.37	10.9	375.98	10.94	376.03	10.94	377.6	10.98	378.42	11
379.2	11	380.81	11						

Manning's n Values num= 4

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
0	.035	204.22	.025	237.44	.035	380.81	.035

Bank Sta: Left	Right	Coeff Contr.	Expan.
204.22	237.44	.1	.3

Sediment Elevation = 4

Upstream Embankment side slope = 0 horiz. to 1.0 vertical
Downstream Embankment side slope = 0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow = .98
Elevation at which weir flow begins =
Energy head used in spillway design =
Spillway height used in design =
Weir crest shape = Broad Crested

Number of Bridge Coefficient Sets = 1

Low Flow Methods and Data
Energy

Selected Low Flow Methods = Highest Energy Answer

High Flow Method
Energy Only

Additional Bridge Parameters
Add Friction component to Momentum
Do not add Weight component to Momentum
Class B flow critical depth computations use critical depth inside the bridge at the upstream end
Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 50.4*

INPUT
Description:
Station Elevation Data num= 377

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5.92	1.94	5.92	2.04	5.92	3.89	5.92	4.08	5.92
5.83	5.82	6.12	5.8	7.78	5.8	8.17	5.64	9.72	5
10.21	5	11.67	5	12.25	5	13.61	5	14.29	5
15.55	5	16.33	5	17.51	5	18.38	5	19.45	5
20.43	5	21.4	5	22.47	4.78	23.34	4.6	24.51	4.6
25.29	4.6	26.55	4.21	27.23	4	28.59	4	29.18	4
30.63	3.85	31.12	3.8	32.68	3.8	33.06	3.8	34.72	3.8
35.01	3.8	36.76	3.48	36.95	3.44	38.8	3.4	38.9	3.4
40.84	3.4	42.79	3.4	42.88	3.4	44.73	3.4	44.93	3.39
46.67	3.32	46.97	3.26	48.62	2.92	49.01	2.92	50.56	2.92
51.05	2.92	52.52	2.92	53.1	2.87	54.46	2.76	55.14	2.76
56.41	2.76	57.18	2.71	58.35	2.64	59.23	2.64	60.29	2.64
61.27	2.64	62.24	2.64	63.31	2.55	64.18	2.48	65.35	2.41
66.13	2.36	67.39	2.54	68.07	2.64	69.43	2.64	70.02	2.64
71.48	2.64	71.96	2.64	73.52	2.77	73.9	2.77	75.56	2.65
75.85	2.58	77.6	2.34	77.79	2.34	79.64	2.2	79.74	2.2
81.68	2.62	83.63	2.7	83.73	2.7	85.58	2.67	85.77	2.66
87.53	2.82	87.81	2.84	89.47	2.89	89.86	2.9	91.41	2.9
91.9	2.9	93.36	3.33	93.94	3.5	95.3	3.62	95.99	3.68
97.25	3.75	98.03	3.8	99.19	4	100.07	4.16	101.14	4.29
102.11	4.4	103.08	4.4	104.15	4.4	105.02	4.4	106.19	4.4
106.97	4.4	108.23	4.4	108.91	4.4	110.28	4.23	110.86	4.16
112.32	4.04	112.8	4	114.36	4	114.75	4	116.4	3.97
116.69	3.96	118.44	3.64	118.64	3.6	120.48	3.6	120.59	3.6
122.53	3.44	124.48	3	124.58	2.99	126.42	2.8	126.62	2.82
128.37	2.96	128.66	3.01	130.31	3.32	130.7	3.38	132.25	3.6
132.74	3.6	134.2	3.6	134.79	3.6	136.14	3.6	136.83	3.6
138.09	3.6	138.87	3.76	140.03	4	140.91	4	141.98	4
142.95	4	143.92	4	144.99	4	145.87	4	147.04	4
147.81	4	149.08	4	149.75	4	151.12	4	151.7	4
153.16	4	153.65	4	155.2	4.32	155.6	4.4	157.24	4.4
157.54	4.38	159.29	4.28	159.49	4.23	161.34	3.8	161.43	3.79
163.37	3.68	165.32	3.57	165.42	3.56	167.26	2.91	167.46	2.84
169.21	2.74	169.5	2.72	171.15	3.01	171.54	3.08	173.1	3.49
173.59	3.62	175.04	3.75	175.63	3.8	176.98	3.8	177.67	3.7
178.93	3.52	179.71	3.47	180.87	3.4	181.75	3.4	182.82	3.71
183.79	4	184.76	4	185.84	4	186.71	4	187.88	4
188.66	4	189.92	4	190.61	4	191.96	4	192.55	4
194	3.7	194.49	3.6	196.05	3.6	196.44	3.6	198.1	3.6
198.38	3.6	200.14	3.6	200.33	3.6	202.18	3.6	202.27	3.6
204.22	3.6	205.6	2.88	206.98	2.77	208.35	2.53	209.73	2.12
210.42	1.82	211.11	1.55	212.49	1.37	213.86	1.24	215.24	1.12
216.62	1	217.66	1	218.7	1	219.75	1	220.79	1
221.83	1	223.25	1.16	224.67	1.27	226.09	1.37	227.03	1.48
227.51	1.53	228.93	1.94	230.35	2.34	231.77	2.45	232.22	2.56
233.19	2.85	234.61	3.1	236.02	3.35	237.44	3.54	239.05	3.58
239.83	3.6	240.66	3.6	242.22	3.6	242.27	3.6	243.89	3.68
244.61	3.9	245.5	4.25	247	4.48	247.1	4.49	248.72	4.57
249.39	4.6	250.33	4.6	251.78	4.6	251.94	4.63	253.55	4.96
254.16	5.08	255.16	5.13	256.55	5.2	256.77	5.2	258.39	5.2
258.95	5.41	259.99	5.8	261.34	5.8	261.6	5.8	263.22	5.8
263.73	5.8	264.83	5.8	266.12	5.8	266.44	5.8	268.05	5.8

268.51	5.86	269.66	6	270.9	6	271.27	6	272.88	6
273.29	6.1	274.49	6.4	275.68	6.4	276.1	6.4	277.72	6.4
278.07	6.4	279.32	6.4	280.45	6.62	280.94	6.72	282.55	6.88
282.84	6.89	284.15	6.96	285.23	7.01	285.77	7.04	287.38	7.36
287.62	7.39	288.99	7.56	290.01	7.59	290.6	7.6	292.22	7.6
292.4	7.6	293.82	7.6	294.79	7.77	295.44	7.88	297.05	8
297.18	8	298.65	8	299.57	8	300.27	8	301.88	8
301.97	8	303.49	8	304.36	8	305.1	8	306.72	8
306.74	8	308.32	8	309.13	8	309.93	8.02	311.52	8.06
311.55	8.06	313.15	8.06	313.91	8.06	314.77	8.06	316.3	8.06
316.38	8.06	317.99	8.06	318.69	8.06	319.6	8.11	321.08	8.18
321.21	8.19	322.82	8.27	323.47	8.3	324.43	8.37	325.86	8.48
326.05	8.49	327.65	8.62	328.24	8.66	329.27	8.66	330.63	8.66
330.88	8.7	332.48	8.99	333.02	9.08	334.1	9.3	335.41	9.56
335.71	9.62	337.32	9.94	337.8	10.04	338.93	10.1	340.19	10.16
340.54	10.16	342.15	10.16	342.59	10.16	343.77	10.19	344.98	10.22
345.38	10.22	346.98	10.22	347.37	10.22	348.6	10.22	349.76	10.22
350.21	10.23	351.82	10.27	352.15	10.28	353.43	10.38	354.53	10.46
355.04	10.49	356.65	10.57	356.92	10.58	358.26	10.61	359.31	10.64
359.87	10.64	361.48	10.64	361.7	10.64	363.1	10.68	364.09	10.7
364.71	10.72	366.32	10.76	366.48	10.76	367.93	10.8	368.87	10.82
369.54	10.82	371.15	10.82	371.26	10.82	372.76	10.86	373.65	10.88
374.37	10.9	375.98	10.94	376.03	10.94	377.6	10.98	378.42	11
379.2	11	380.81	11						

Manning's n Values num= 4

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
0	.035	204.22	.025	237.44	.035	380.81	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
204.22	237.44	16.2	16.2	16.2	.1	.3

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 31.2*

INPUT
Description:
Station Elevation Data num= 377

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	4.56	1.92	4.56	2.02	4.56	3.85	4.56	4.04	4.56
5.77	4.42	6.06	4.4	7.7	4.4	8.08	4.32	9.62	4
10.1	4	11.55	4	12.12	4	13.48	4	14.15	4
15.4	4	16.17	4	17.33	4	18.2	4	19.25	4
20.22	4	21.18	4	22.24	3.89	23.1	3.8	24.26	3.8
25.03	3.8	26.28	3.6	26.95	3.5	28.3	3.5	28.88	3.5
30.32	3.42	30.8	3.4	32.34	3.4	32.72	3.4	34.36	3.4
34.65	3.4	36.38	3.24	36.57	3.22	38.41	3.2	38.51	3.2
40.43	3.2	42.36	3.2	42.45	3.2	44.28	3.2	44.47	3.2
46.2	3.16	46.49	3.13	48.13	2.96	48.51	2.96	50.05	2.96
50.53	2.96	51.98	2.96	52.56	2.94	53.9	2.88	54.58	2.88
55.83	2.88	56.6	2.86	57.75	2.82	58.62	2.82	59.67	2.82
60.64	2.82	61.6	2.82	62.66	2.78	63.53	2.74	64.69	2.7
65.46	2.68	66.71	2.77	67.38	2.82	68.73	2.82	69.31	2.82
70.75	2.82	71.23	2.82	72.77	2.88	73.15	2.85	74.79	2.68
75.08	2.58	76.81	2.07	77	2.05	78.83	1.8	78.93	1.8
80.85	1.96	82.78	2	82.87	2	84.7	1.9	84.89	1.88
86.63	2.09	86.91	2.12	88.56	2.18	88.95	2.2	90.48	2.2
90.97	2.2	92.41	2.77	92.99	3	94.33	3.16	95.01	3.24
96.26	3.34	97.03	3.4	98.18	3.67	99.05	3.88	100.11	4.05
101.07	4.2	102.03	4.2	103.09	4.2	103.95	4.2	105.11	4.2
105.88	4.2	107.13	4.2	107.8	4.2	109.15	4.12	109.73	4.08
111.17	4.02	111.65	4	113.19	4	113.58	4	115.22	3.98
115.51	3.98	117.24	3.82	117.43	3.8	119.26	3.8	119.36	3.8
121.28	3.72	123.21	3.5	123.31	3.49	125.13	3.4	125.33	3.41
127.06	3.48	127.35	3.51	128.98	3.66	129.37	3.69	130.9	3.8
131.39	3.8	132.83	3.8	133.41	3.8	134.75	3.8	135.43	3.8
136.68	3.8	137.45	3.88	138.61	4	139.48	4	140.54	4
141.5	4	142.46	4	143.52	4	144.39	4	145.54	4
146.31	4	147.56	4	148.23	4	149.58	4	150.16	4
151.6	4	152.08	4	153.62	4.16	154.01	4.2	155.64	4.2

155.93	4.18	157.67	4.04	157.86	3.98	159.69	3.4	159.78	3.39
161.7	3.24	163.63	3.09	163.73	3.08	165.56	2.21	165.76	2.12
167.49	1.98	167.78	1.96	169.41	2.35	169.8	2.44	171.34	2.99
171.82	3.16	173.26	3.33	173.84	3.4	175.18	3.4	175.86	3.35
177.11	3.26	177.88	3.24	179.03	3.2	179.9	3.2	180.96	3.62
181.92	4	182.88	4	183.94	4	184.81	4	185.96	4
186.73	4	187.98	4	188.66	4	190.01	4	190.59	4
192.03	3.85	192.51	3.8	194.06	3.8	194.44	3.8	196.08	3.8
196.36	3.8	198.1	3.8	198.29	3.8	200.12	3.8	200.21	3.8
202.14	3.8	203.83	2.94	205.52	2.88	207.21	2.67	208.9	2.21
209.74	1.86	210.58	1.52	212.27	1.33	213.96	1.22	215.65	1.11
217.34	1	218.06	1	218.78	1	219.5	1	220.22	1
220.95	1	222.66	1.18	224.36	1.28	226.08	1.39	227.21	1.51
227.79	1.57	229.5	2.07	231.21	2.57	232.92	2.67	233.47	2.81
234.63	3.12	236.34	3.35	238.05	3.57	239.76	3.72	241.23	3.77
241.95	3.8	242.72	3.8	244.14	3.8	244.19	3.8	245.68	3.91
246.34	4.05	247.15	4.34	248.53	4.64	248.63	4.65	250.11	4.76
250.73	4.8	251.59	4.8	252.92	4.8	253.08	4.84	254.55	5.28
255.12	5.44	256.04	5.51	257.31	5.6	257.51	5.6	259	5.6
259.52	5.71	260.47	5.9	261.71	5.9	261.95	5.9	263.43	5.9
263.91	5.9	264.91	5.9	266.1	5.9	266.39	5.9	267.87	5.9
268.29	5.93	269.35	6	270.49	6	270.83	6	272.31	6
272.68	6.05	273.79	6.2	274.88	6.2	275.27	6.2	276.75	6.2
277.07	6.2	278.23	6.2	279.27	6.31	279.71	6.36	281.19	6.44
281.46	6.45	282.67	6.48	283.66	6.51	284.15	6.52	285.63	6.68
285.85	6.7	287.11	6.78	288.04	6.79	288.59	6.8	290.07	6.8
290.24	6.8	291.55	6.8	292.43	6.88	293.03	6.94	294.51	7
294.63	7	295.99	7	296.82	7	297.47	7	298.95	7
299.03	7	300.43	7	301.22	7	301.91	7	303.39	7
303.42	7	304.87	7	305.61	7	306.34	7.03	307.81	7.08
307.83	7.08	309.3	7.08	310	7.08	310.79	7.08	312.19	7.08
312.27	7.08	313.75	7.08	314.39	7.08	315.23	7.14	316.58	7.24
316.7	7.25	318.19	7.36	318.78	7.4	319.66	7.5	320.97	7.64
321.15	7.66	322.62	7.82	323.17	7.88	324.11	7.88	325.36	7.88
325.58	7.94	327.06	8.31	327.56	8.44	328.55	8.73	329.75	9.08
330.02	9.16	331.51	9.59	331.94	9.72	332.98	9.8	334.14	9.88
334.47	9.88	335.94	9.88	336.34	9.88	337.43	9.92	338.54	9.96
338.9	9.96	340.38	9.96	340.73	9.96	341.86	9.96	342.93	9.96
343.34	9.98	344.83	10.03	345.12	10.04	346.3	10.17	347.32	10.28
347.79	10.31	349.26	10.42	349.51	10.44	350.74	10.48	351.71	10.52
352.22	10.52	353.7	10.52	353.9	10.52	355.18	10.57	356.09	10.6
356.66	10.62	358.14	10.67	358.29	10.68	359.62	10.73	360.48	10.76
361.1	10.76	362.58	10.76	362.68	10.76	364.06	10.81	364.87	10.84
365.54	10.86	367.02	10.92	367.07	10.92	368.5	10.97	369.26	11
369.98	11	371.46	11						

Manning's n Values num= 4

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
0	.035	202.14	.025	239.76	.035	371.46	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
202.14	239.76	16.2	16.2	16.2	.1	.3

Sediment Elevation = 4

CROSS SECTION

RIVER: THC
REACH: RESTORED RS: 12

INPUT
Description:
Station Elevation Data num= 182

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	3.2	2	3.2	4	3.2	6	3	8	3
10	3	12	3	14	3	16	3	18.01	3
20.01	3	22.01	3	24.01	3	26.01	3	28.01	3
30.01	3	32.01	3	34.01	3	36.01	3	38.01	3
40.01	3	42.01	3	44.01	3	46.01	3	48.01	3
50.01	3	52.02	3	54.02	3	56.02	3	58.02	3
60.02	3	62.02	3	64.02	3	66.02	3	68.02	3
70.02	3	72.02	3	74.02	2.7	76.02	1.8	78.02	1.4
80.02	1.3	82.02	1.3	84.02	1.1	86.02	1.4	88.03	1.5
90.03	1.5	92.03	2.5	94.03	2.8	96.03	3	98.03	3.6

100.03	4	102.03	4	104.03	4	106.03	4	108.03	4
110.03	4	112.03	4	114.03	4	116.03	4	118.03	4
120.03	4	122.04	4	124.04	4	126.04	4	128.04	4
130.04	4	132.04	4	134.04	4	136.04	4	138.04	4
140.04	4	142.04	4	144.04	4	146.04	4	148.04	4
150.04	4	152.04	4	154.04	4	156.05	3.8	158.05	3
160.05	2.8	162.05	2.6	164.05	1.4	166.05	1.2	168.05	1.8
170.05	2.7	172.05	3	174.05	3	176.05	3	178.05	3
180.05	4	182.05	4	184.05	4	186.05	4	188.05	4
190.05	4	192.06	4	194.06	4	196.06	4	198.06	4
200.06	4	202.06	3	204.06	3	206.06	2.8	208.06	2.3
210.06	1.5	212.06	1.3	214.06	1.2	216.06	1.1	218.06	1
220.06	1	222.06	1.2	224.06	1.3	226.07	1.4	228.07	1.6
230.07	2.2	232.07	2.8	234.07	2.9	236.07	3.4	238.07	3.6
240.07	3.8	242.07	3.9	244.07	4	246.07	4	248.07	4.2
250.07	4.8	252.07	5	254.07	5	256.07	5.8	258.07	6
260.08	6	262.08	6	264.08	6	266.08	6	268.08	6
270.08	6	272.08	6	274.08	6	276.08	6	278.08	6
280.08	6	282.08	6	284.08	6	286.08	6	288.08	6
290.08	6	292.08	6	294.08	6	296.09	6	298.09	6
300.09	6	302.09	6	304.09	6.1	306.09	6.1	308.09	6.1
310.09	6.1	312.09	6.3	314.09	6.5	316.09	6.8	318.09	7.1
320.09	7.1	322.09	7.8	324.09	8.6	326.09	9.4	328.09	9.6
330.1	9.6	332.1	9.7	334.1	9.7	336.1	9.7	338.1	9.8
340.1	10.1	342.1	10.3	344.1	10.4	346.1	10.4	348.1	10.5
350.1	10.6	352.1	10.7	354.1	10.7	356.1	10.8	358.1	10.9
360.1	11	362.1	11						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	200.06	.025	242.07	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
200.06	242.07	0	0	0	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
0	65.24	9.15	F

Sediment Elevation = 4

SUMMARY OF MANNING'S N VALUES

River:THC

Reach	River Sta.	n1	n2	n3	n4
RESTORED	1045	.035	.025	.035	
RESTORED	996	.035	.025	.035	
RESTORED	924	.035	.025	.035	
RESTORED	826	.035	.025	.035	
RESTORED	701	.035	.025	.035	
RESTORED	630	Bridge			
RESTORED	559	.035	.025	.035	
RESTORED	511	.035	.025	.035	
RESTORED	436	.035	.025	.035	
RESTORED	360	.035	.025	.035	
RESTORED	256	.035	.025	.035	
RESTORED	191	.035	.025	.035	
RESTORED	108	.035	.025	.035	
RESTORED	90	Bridge			
RESTORED	50.4*	.035	.025	.035	.035
RESTORED	31.2*	.035	.025	.035	.035
RESTORED	12	.035	.025	.035	

SUMMARY OF REACH LENGTHS

River: THC

Reach	River Sta.	Left	Channel	Right

RESTORED	1045	47	47	47
RESTORED	996	74	74	74
RESTORED	924	99	99	99
RESTORED	826	126	126	126
RESTORED	701	137	137	137
RESTORED	630	Bridge		
RESTORED	559	50	50	50
RESTORED	511	96	96	96
RESTORED	436	73	73	73
RESTORED	360	140	140	140
RESTORED	256	60	60	60
RESTORED	191	63	63	63
RESTORED	108	48.6	48.6	48.6
RESTORED	90	Bridge		
RESTORED	50.4*	16.2	16.2	16.2
RESTORED	31.2*	16.2	16.2	16.2
RESTORED	12	0	0	0

Profile Output Table - Standard Table 1

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
RESTORED	12	50-year	716.00	4.00	4.80	4.80	5.20	0.014869	6.26	147.28	250.10	1.23
RESTORED	12	100-year	826.00	4.00	4.88	4.88	5.32	0.014486	6.58	161.93	250.89	1.23
RESTORED	12	500-year	1077.00	4.00	5.07	5.07	5.58	0.012851	7.06	197.71	254.25	1.20
RESTORED	31.2*	50-year	716.00	4.00	5.21		5.31	0.002365	3.28	295.13	254.31	0.53
RESTORED	31.2*	100-year	826.00	4.00	5.32		5.43	0.002329	3.45	323.33	254.69	0.53
RESTORED	31.2*	500-year	1077.00	4.00	5.55		5.69	0.002278	3.80	382.82	256.65	0.54
RESTORED	50.4*	50-year	716.00	4.00	5.24		5.35	0.002812	3.64	277.17	249.36	0.58
RESTORED	50.4*	100-year	826.00	4.00	5.35		5.48	0.002752	3.81	304.54	249.92	0.58
RESTORED	50.4*	500-year	1077.00	4.00	5.58		5.73	0.002649	4.15	362.41	251.09	0.58
RESTORED	90		Bridge									
RESTORED	108	50-year	716.00	4.00	5.40	4.86	5.54	0.003294	4.28	257.34	227.97	0.64
RESTORED	108	100-year	826.00	4.00	5.51	5.07	5.66	0.003530	4.64	280.85	240.55	0.67
RESTORED	108	500-year	1077.00	4.00	5.73	5.21	5.91	0.003359	4.97	335.74	241.77	0.67
RESTORED	191	50-year	716.00	4.00	5.59	4.93	5.71	0.002123	3.58	289.65	287.38	0.51
RESTORED	191	100-year	826.00	4.00	5.71	5.00	5.83	0.002120	3.76	316.57	287.83	0.52
RESTORED	191	500-year	1077.00	4.00	5.93	5.00	6.08	0.002181	4.15	369.50	288.71	0.54
RESTORED	256	50-year	716.00	4.00	5.72	5.00	5.84	0.002229	3.87	284.10	341.69	0.53

RESTORED	256	100-year	826.00	4.00	5.83	5.00	5.96	0.002225	4.05	310.80	343.99	0.54
RESTORED	256	500-year	1077.00	4.00	6.06	5.00	6.22	0.002265	4.43	366.06	379.13	0.56
RESTORED	360	50-year	716.00	4.00	5.96	5.00	6.04	0.000996	2.89	346.16	532.51	0.37
RESTORED	360	100-year	826.00	4.00	6.08	5.00	6.17	0.001038	3.07	374.34	544.17	0.38
RESTORED	360	500-year	1077.00	4.00	6.32	5.00	6.44	0.001130	3.45	431.60	546.80	0.40
RESTORED	436	50-year	716.00	4.00	5.90	5.49	6.25	0.003759	5.56	170.32	293.37	0.71
RESTORED	436	100-year	826.00	4.00	5.99	5.72	6.40	0.004129	6.02	181.27	293.77	0.75
RESTORED	436	500-year	1077.00	4.00	6.17	5.96	6.73	0.005026	7.03	201.88	308.73	0.84
RESTORED	511	50-year	716.00	4.00	6.28	5.32	6.45	0.001126	3.45	237.08	318.26	0.40
RESTORED	511	100-year	826.00	4.00	6.43	5.44	6.62	0.001197	3.70	255.20	319.08	0.42
RESTORED	511	500-year	1077.00	4.00	6.74	5.74	6.98	0.001323	4.21	293.40	320.67	0.45
RESTORED	559	50-year	716.00	4.00	6.13		6.66	0.004237	6.38	147.56	108.56	0.77
RESTORED	559	100-year	826.00	4.00	6.27		6.84	0.004348	6.74	162.09	108.70	0.79
RESTORED	559	500-year	1077.00	4.00	6.55		7.22	0.004517	7.42	192.68	108.98	0.82
RESTORED	630		Bridge									
RESTORED	701	50-year	716.00	4.00	7.21	5.90	7.55	0.002409	6.35	175.81	75.30	0.62
RESTORED	701	100-year	826.00	4.00	7.43	5.97	7.81	0.002460	6.71	193.04	78.95	0.64
RESTORED	701	500-year	1077.00	4.00	7.99	5.97	8.40	0.002227	7.06	238.16	81.65	0.62
RESTORED	826	50-year	716.00	4.00	7.18	7.06	8.19	0.005613	8.24	92.34	65.26	0.89
RESTORED	826	100-year	826.00	4.00	7.33	7.30	8.52	0.006201	8.95	98.20	65.97	0.94
RESTORED	826	500-year	1077.00	4.00	7.78	7.78	9.22	0.006230	9.88	116.45	69.62	0.97
RESTORED	924	50-year	716.00	5.80	10.67	10.67	12.30	0.005802	11.31	84.94	31.63	0.98
RESTORED	924	100-year	826.00	5.80	11.18	11.18	12.75	0.004936	11.26	102.03	35.23	0.92
RESTORED	924	500-year	1077.00	5.80	11.85	11.85	13.63	0.004889	12.25	126.41	38.12	0.94
RESTORED	996	50-year	716.00	5.10	12.13		12.55	0.000921	5.91	172.25	49.38	0.42
RESTORED	996	100-year	826.00	5.10	12.54		12.99	0.000922	6.17	192.85	50.93	0.42
RESTORED	996	500-year	1077.00	5.10	13.38		13.89	0.000926	6.70	237.41	54.70	0.43

RESTORED	1045	50-year	716.00	5.20	12.06	10.07	12.66	0.001217	6.89	132.05	57.90	0.48
RESTORED	1045	100-year	826.00	5.20	12.43	10.42	13.11	0.001303	7.40	142.71	58.59	0.51
RESTORED	1045	500-year	1077.00	5.20	13.17	11.14	14.06	0.001489	8.49	165.16	60.78	0.55

```
                    HEC-RAS Version 4.0.0 March 2008
                      U.S. Army Corps of Engineers
                     Hydrologic Engineering Center
                           609 Second Street
                           Davis, California

            X     X  XXXXXX   XXXX        XXXX       XX       XXXX
            X     X  X       X    X       X   X     X  X     X
            X     X  X       X            X   X    X    X    X
            XXXXXXX  XXXX    X       XXX  XXXX     XXXXXX     XXXX
            X     X  X       X            X  X     X    X         X
            X     X  X       X    X       X   X    X    X         X
            X     X  XXXXXX   XXXX        X    X   X    X    XXXXX
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PROJECT DATA
Project Title: THC Braided Channel
Project File : THC.prj
Run Date and Time: 7/21/2009 9:59:14 AM

Project in English units

PLAN DATA

Plan Title: tsunami - twin 10X6 culvts
Plan File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.p04

Geometry Title: THC RESTORED CHANNEL - Twin 10X6 clvts
Geometry File : C:\Desktop\Doyle\OUTBOX\Models\RAS\THC.g02

Flow Title :
Flow File :

Plan Summary Information:

Number of:				
Cross Sections =	15	Multiple Openings =	0
Culverts =	1	Inline Structures =	0
Bridges =	1	Lateral Structures =	0

Computational Information
    Water surface calculation tolerance = 0.01
    Critical depth calculation tolerance = 0.01
    Maximum number of iterations = 20
    Maximum difference tolerance = 0.3
    Flow tolerance factor = 0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method: Average Conveyance
    Computational Flow Regime: Subcritical Flow

Profile Output Table - Standard Table 1

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
RESTORED	12	Max WS	-1186.70	1.00	11.00	3.99	11.00	0.000009	-0.76	2374.08	360.10	0.05
RESTORED	31.2*	Max WS	-1153.16	1.00	11.00		11.00	0.000010	-0.79	2307.20	371.46	0.05
RESTORED	50.4*	Max WS	-1143.02	1.00	11.00		11.01	0.000011	-0.83	2230.11	378.42	0.05
RESTORED	90		Culvert									

RESTORED	108	Max WS	-484.93	1.00	9.42	9.42	0.000006	-0.57	1470.68	284.11	0.04
RESTORED	191	Max WS	-444.89	1.00	9.43	9.43	0.000003	-0.38	1816.74	332.10	0.02
RESTORED	256	Max WS	-397.23	1.00	9.43	9.43	0.000002	-0.31	2130.68	429.23	0.02
RESTORED	360	Max WS	-245.18	1.00	9.44	9.44	0.000000	-0.13	3189.23	598.20	0.01
RESTORED	436	Max WS	-158.77	0.00	9.44	9.44	0.000000	-0.12	2330.94	511.65	0.01
RESTORED	511	Max WS	-69.09	1.80	9.44	9.44	0.000000	-0.05	1904.91	359.50	0.00
RESTORED	559	Max WS	-42.13	0.00	9.44	9.44	0.000000	-0.07	600.37	141.19	0.01
RESTORED	630		Bridge								
RESTORED	701	Max WS	-42.13	0.00	9.43	9.43	0.000000	-0.10	413.92	89.91	0.01
RESTORED	826	Max WS	-19.37	4.00	9.44	9.44	0.000000	-0.11	187.93	76.06	0.01
RESTORED	924	Max WS	-8.32	5.80	9.44	9.44	0.000003	-0.20	50.28	25.12	0.02
RESTORED	996	Max WS	-4.12	5.10	9.44	9.44	0.000000	-0.07	63.88	25.60	0.01
RESTORED	1045	Max WS	0.01	5.20	9.45	9.45	0.000000	0.00	63.99	52.75	0.00

Pier Scour

All piers have the same scour depth

Input Data

Pier Shape:	Round nose
Pier Width (ft):	6.50
Grain Size D50 (mm):	0.15000
Depth Upstream (ft):	1.92
Velocity Upstream (ft/s):	3.98
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	120.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	6.96
Froude #:	0.51
Equation:	CSU equation

Appendix C: Structure Plans

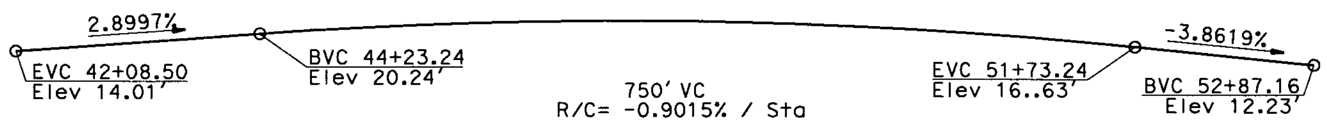
INCOMPLETE PLAN FOR DESIGN STUDY PRINTED
DATE: 24-NOV-2008
Office of Structure Design
STATE OF CALIFORNIA

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
04	SF	1,101			

REGISTERED CIVIL ENGINEER X DATE

PLANS APPROVAL DATE

P. E. LUTZ No. C55839 Exp. 12-31-10 CIVIL STATE OF CALIFORNIA REGISTERED PROFESSIONAL ENGINEER



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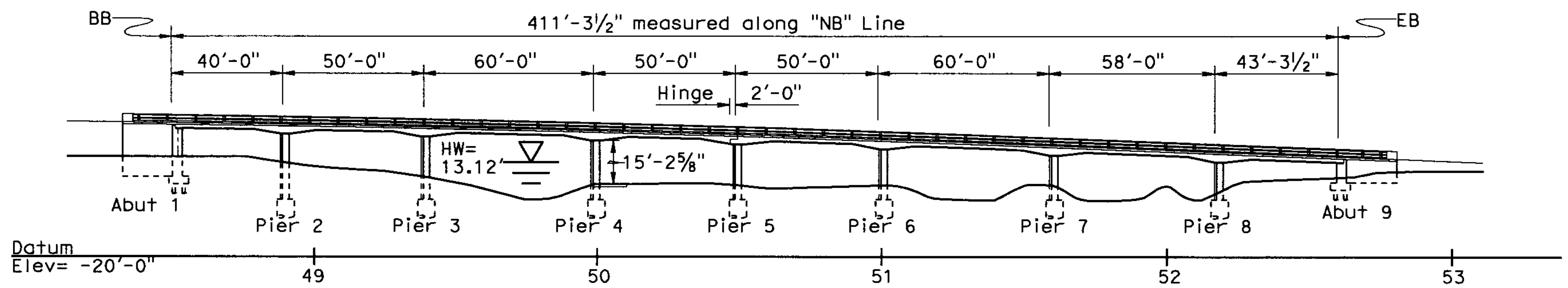
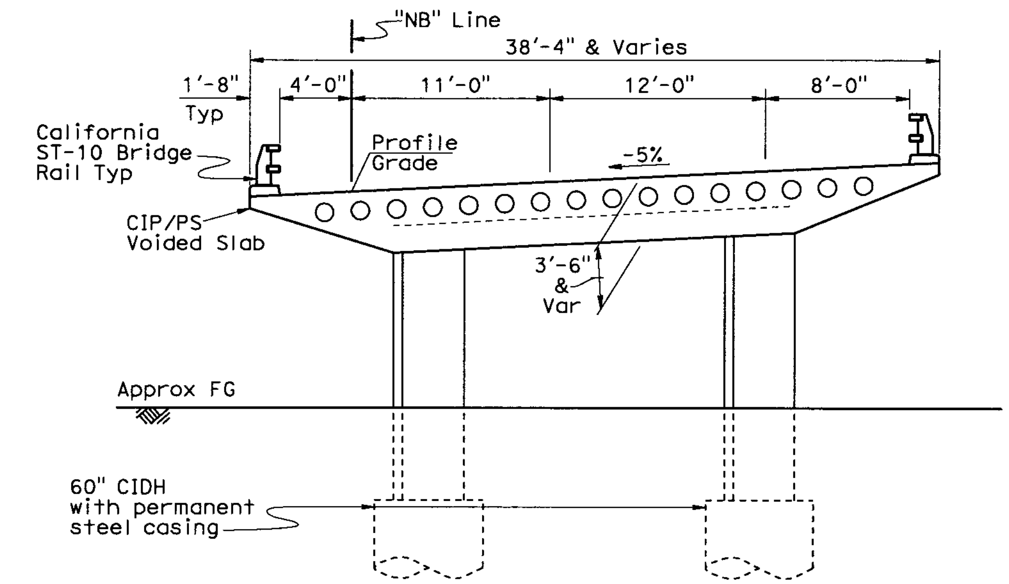
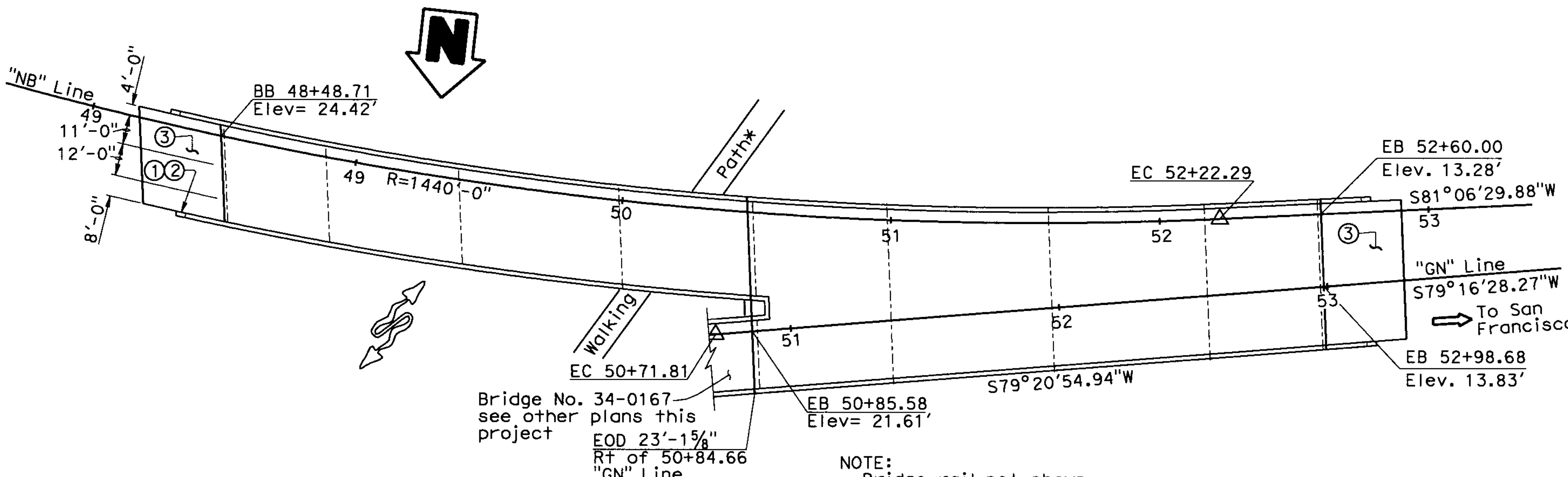
No Scale



ELEVATION
1" = 30'



SECTION AT PIER 2
3/16" = 1'



PLAN
1" = 30'

NOTE:
Bridge rail not shown

* Proposed path

SKEW ANGLE DATA

Location	∠
Abut 1	14°24'53.46"
Pier 2	12°52'28.77"
Pier 3	10°53'06.80"
Pier 4	8°29'52.44"
Pier 5	6°30'30.46"

SKEW ANGLE DATA

Location	∠
Pier 6	4°31'08.49"
Pier 7	2°07'54.12"
Pier 8	0°10'33.76"
Abut 9	0°23'53.13"

CURVE DATA

Line	R	Δ	T	L
"NB"	1440.00'	20°45'49.86"	263.82'	521.85'
"GN"	790.00'	33°25'15.20"	237.17'	460.81'

NOTES:

1. Architectural treatment, size and shape of overhang/columns to be determined
2. For Hydrologic Summary see "Foundation Plan" sheet

① Paint "BR NO 34-0164L"

② Paint "TENNESSEE HOLLOW NB"

③ Structure Approach Type N(30D)

ALTERNATIVE 1

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE

DESIGN	BY P. Lutz	CHECKED X	LOAD & RESISTANCE FACTOR DESIGN	LIVE LOADING: HL93 W/"LOW-BOY"; PERMIT DESIGN VEHICLE
DETAILS	BY P. Lutz/Tim Fairall	CHECKED X	LAYOUT	BY P. Lutz/Tim Fairall · CHECKED X
QUANTITIES	BY X	CHECKED X	SPECIFICATIONS	BY X · PLANS AND SPECS COMPARED X

X
DESIGN ENGINEER

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES
STRUCTURE DESIGN
DESIGN BRANCH 9

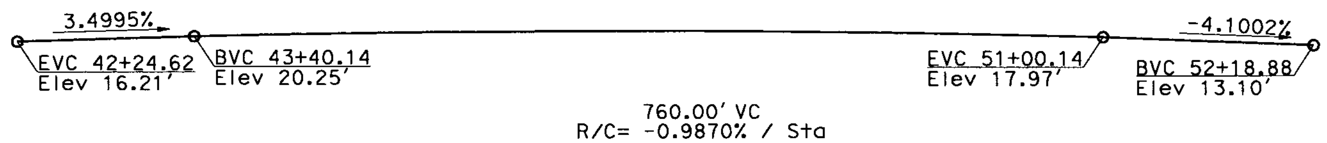
BRIDGE NO. 34-0164R
POST MILE X

TENNESSEE HOLLOW NB
GENERAL PLAN

CU 04
EA 163700

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES 04-08-08 10-23-08
SHEET 1 OF X



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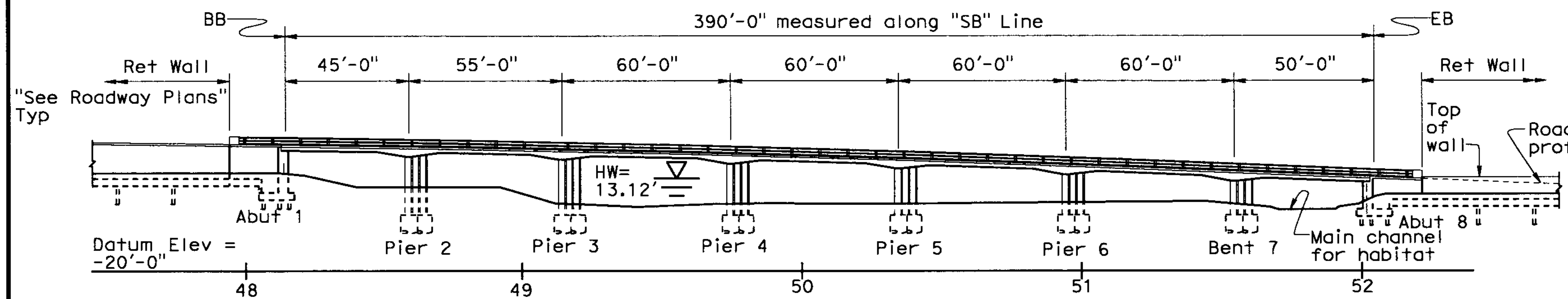
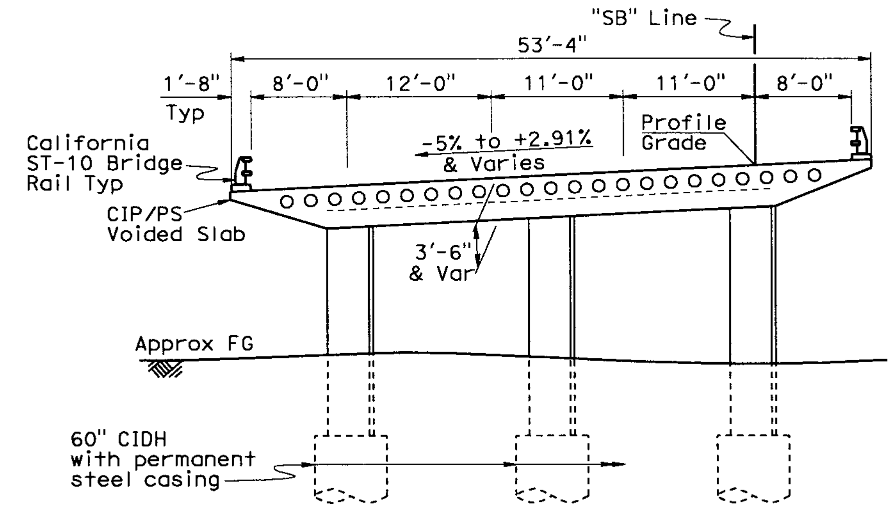
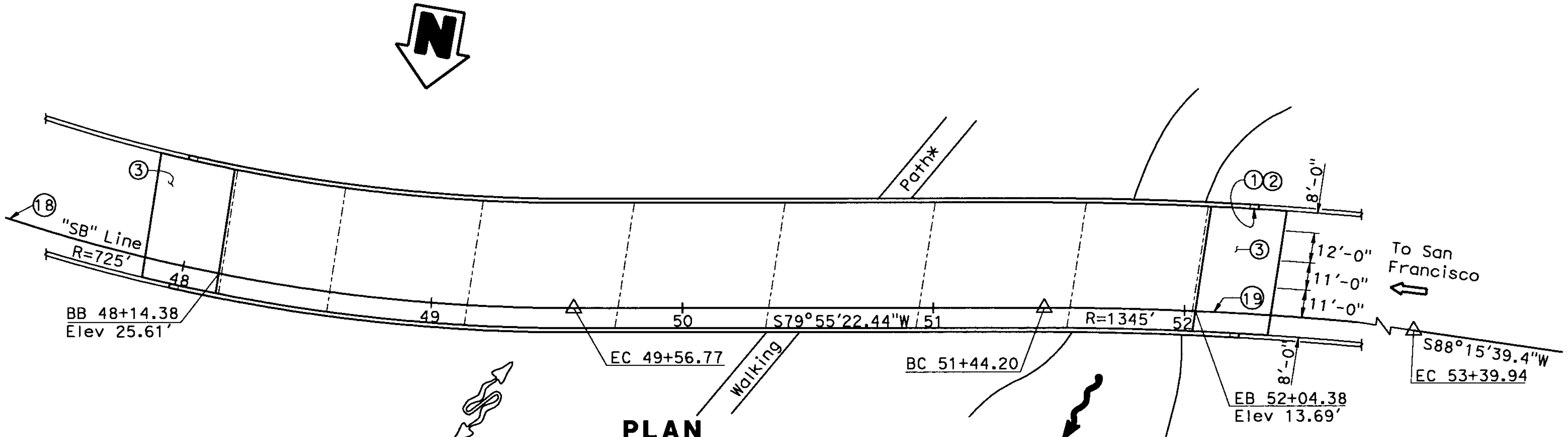


ELEVATION
1" = 30'

NOTES:
Not all piles shown



TYPICAL SECTION
1/8" = 1'



PLAN
1" = 30'

NOTES:
Bridge Rail not shown
* Proposed path

NOTES:
1. Architectural treatment, size and shape of overhang/columns to be determined
2. For Hydrologic Summary see "Foundation Plan" sheet

① Paint "BR NO 34-0164L"
② Paint "TENNESSEE HOLLOW SB"
③ Structure Approach Type N(30D)

SKEW ANGLE DATA

Location	∠
Abut 1	2°19'56.62"
Pier 2	1°7'30.08"
Pier 3	5°28'17.76"
Piers 4 thru 6	8°49'17.85"
Pier 7	8°23'16.68"
Abut 8	6°18'41.70"

CURVE DATA

Curve	R	Δ	T	L
18	725.00'	62°25'24.65"	439.28'	789.88'
19	1345.00'	8°20'16.99"	98.04'	195.73'

Reserved Quantities

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
04	SF	1,101			

REGISTERED CIVIL ENGINEER DATE X

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER P. E. LUTZ No. C55839 Exp. 12-31-10 CIVIL STATE OF CALIFORNIA

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ALTERNATIVE 1

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE

DESIGN	BY P. Lutz	CHECKED X	LOAD & RESISTANCE FACTOR DESIGN	LIVE LOADING: HL93 W/"LOW-BOY"; PERMIT DESIGN VEHICLE
DETAILS	BY P. Lutz/T. Fariall	CHECKED X	LAYOUT	BY P. Lutz; CHECKED X
QUANTITIES	BY X	CHECKED X	SPECIFICATIONS	BY X; PLANS AND SPECS COMPARED X

DESIGN ENGINEER

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES STRUCTURE DESIGN
DESIGN BRANCH 9

BRIDGE NO. 34-0164L
POST MILE X

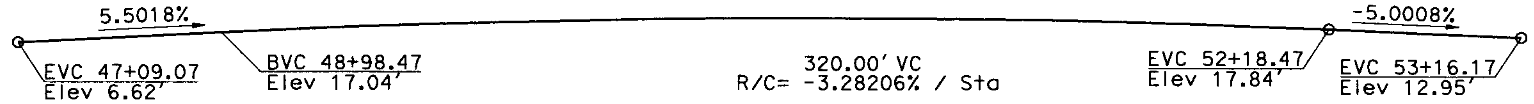
TENNESSEE HOLLOW SB

GENERAL PLAN

CU 04
EA 163700

DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES: 04-04-08, 5-05-08, 09-03-08, 9-16-08, 11-26-08
SHEET 1 OF X

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3



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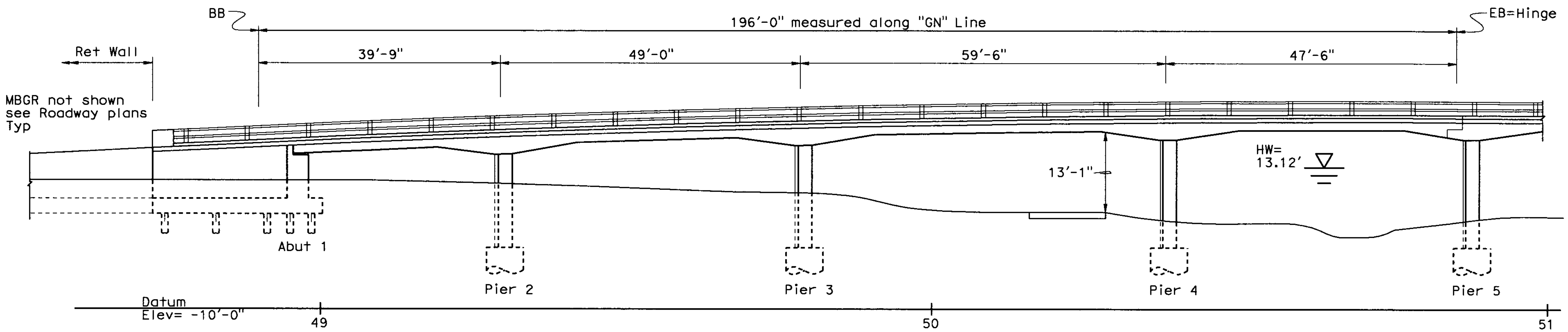
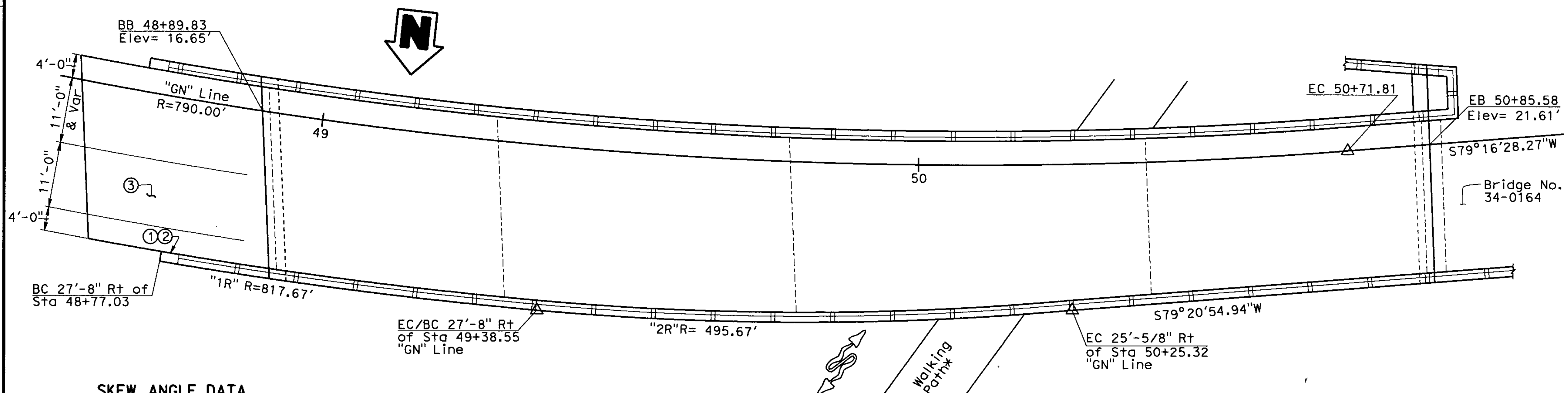


ELEVATION
1" = 10'



PLAN
1" = 10'

NOTE:
* Proposed path

NOTES:
1. Architectural treatment, size and shape of overhang/columns to be determined
2. For Hydrologic Summary see "Foundation Plan" sheet
3. For "Typical Section" and Quantities see "General Plan No. 2" sheet

① Paint "BR NO 34-0164L"
② Paint "GIRARD NB RAMP"
③ Structure Approach Type N(30D)

SKEW ANGLE DATA

Location	∠
Abut 1	10°52'27.03"
Pier 2	8°05'0.92"
Pier 3	4°31'47.28"
Pier 4	0°12'52.14"
℄ Hinge	2°13'54.73"

CURVE DATA

Line	R	Δ	T	L
"GN"	790.00'	33°25'15"	237.17'	460.81'
"1R"	817.67'	4°27'42"	31.94'	63.84'
"2R"	495.67'	10°22'21"	45.04'	89.84'

INCOMPLETE PLAN FOR DESIGN STUDY PRINTED
DATE: 04-22-08
Office of Structure Design
STATE OF CALIFORNIA

South Access to the Golden Gate Bridge

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
04	SF	1,101			

REGISTERED CIVIL ENGINEER   DATE X

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER P. E. LUTZ No. C55839 Exp. 12-31-10 CIVIL STATE OF CALIFORNIA

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ALTERNATIVE 1

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE

GIRARD NORTHBOUND-RAMP

GENERAL PLAN No. 1

X
DESIGN ENGINEER

DESIGN	BY Phil Lutz	CHECKED X	LOAD & RESISTANCE FACTOR DESIGN	LIVE LOADING: HL93 W/"LOW-BOY"; PERMIT DESIGN VEHICLE
DETAILS	BY Tim Fairall	CHECKED X	LAYOUT BY X	CHECKED X
QUANTITIES	BY X	CHECKED X	SPECIFICATIONS BY X	PLANS AND SPECS COMPARED X

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES
STRUCTURE DESIGN
DESIGN BRANCH 9

BRIDGE NO. 34-0167
POST MILE X

CU 04
EA 163700

STRUCTURES DESIGN GENERAL PLAN SHEET (ENGLISH) (REV. 10/25/05)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES: 04-08-08 4-28-08 10-07-08 10-22-08 11-19-08

SHEET 1 OF X

FILE => 34-0167-a-gp01.dgn

STRUCTURES DESIGN GENERAL PLAN SHEET (ENGLISH) (REV.07-24-06)

USERNAME => tfairall DATE PLOTTED => 24-NOV-2008 TIME PLOTTED => 15:22

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
04	SF	1,101			

REGISTERED CIVIL ENGINEER X DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER A. M. TOURZANI No. C50511 Exp. 6-30-09 CIVIL STATE OF CALIFORNIA

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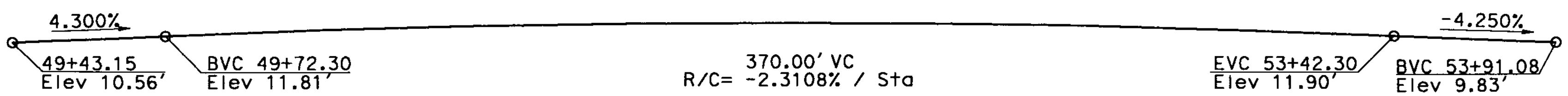
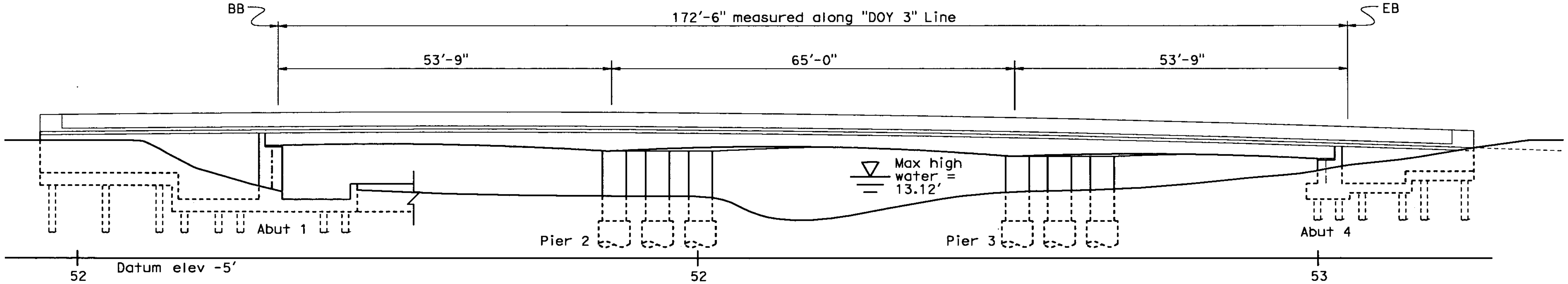
South Access to the Golden Gate Bridge



PROFILE GRADE

No Scale



ELEVATION

1" = 10'

NOTES:

1. Architectural treatment, size and shape of overhang/columns to be determined
2. For "Typical Section" see "General Plan No. 2" sheet
3. For Hydrologic Summary see "Foundation Plan" sheet

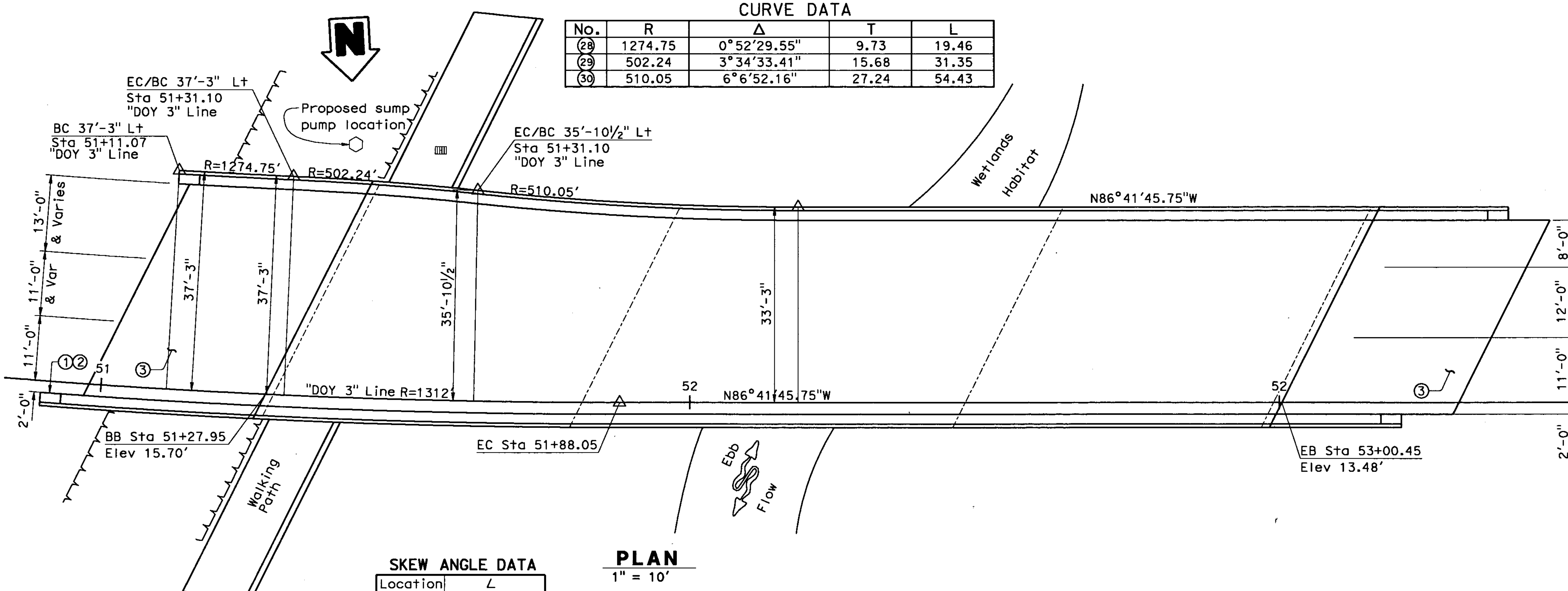
(1) Paint "BR NO 34-0168"

(2) Paint "GORGAS RAMP"

(3) Structure Approach Type N(30D)

CURVE DATA

No.	R	Δ	T	L
(28)	1274.75	0°52'29.55"	9.73	19.46
(29)	502.24	3°34'33.41"	15.68	31.35
(30)	510.05	6°6'52.16"	27.24	54.43



PLAN

1" = 10'

SKEW ANGLE DATA

Location	∠
Abut 1	24°01'45.07"
Pier 2	26°19'00.21"
Pier 3	26°35'40.44"
Abut 4	26°35'40.44"

CURVE DATA

Line	R	Δ	T	L
"Doy 3"	1312'	14°14'14"	163.85'	326.01'

INCOMPLETE PLAN FOR DESIGN STUDY PRINTED

DATE: 31-OCT-2008

Office of Structure Design STATE OF CALIFORNIA

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE

X
DESIGN ENGINEER

DESIGN BY Phil Lutz CHECKED X

DETAILS BY Tim Fairall CHECKED X

QUANTITIES BY X CHECKED X

LOAD & RESISTANCE FACTOR DESIGN

LIVE LOADING: HL93 W/"LOW-BOY"; PERMIT DESIGN VEHICLE

LAYOUT BY X CHECKED X

SPECIFICATIONS BY X PLANS AND SPECS COMPARED X

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

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TECHNICAL REPORT H-75-17

TYPE 16 FLOOD INSURANCE STUDY: TSUNAMI PREDICTIONS FOR MONTEREY AND SAN FRANCISCO BAYS AND PUGET SOUND

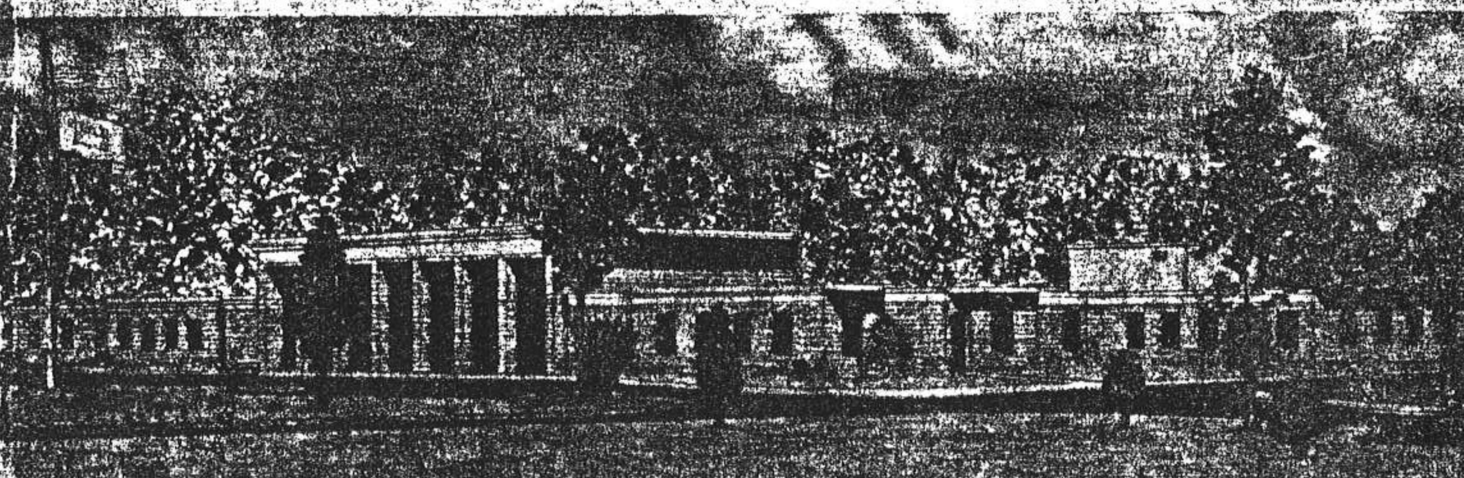
by

Andrew W. Garcia, James R. Houston

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

November 1975

Final Report



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Calculations of runup due to seismic sea waves (tsunamis) of distant origin were made for Monterey and San Francisco Bays and the greater part of Puget Sound. Those areas which are specifically included and excluded are listed. The values presented are interpreted as being equaled or exceeded on the average of once per 100 (R_{100}) or once per 500 (R_{500}) yr, whichever is indicated. All runup values, R_{100} and R_{500}, are referenced to the mean sea
(Continued)

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level datum. The combined effects of astronomical tides and tsunamis are incorporated into the analysis as are certain local effects. The effects of wind waves superimposed on the tsunami have been neglected. The simultaneous occurrence of a storm surge and tsunami is considered highly improbable and therefore unlikely to constitute a 1 in 100- or 1 in 500-yr event.

Analysis of the error attributed to each of the various steps in the procedure results in an estimated maximum average error of about ± 40 percent.

PREFACE

The investigation reported herein was authorized by the Office, Chief of Engineers (OCE), U. S. Army, in a letter dated 14 February 1974 and was performed for the Federal Insurance Administration, Department of Housing and Urban Development, under Inter-Agency Agreements IAA-H-19-74, Project Order No. 9, and IAA-H-19-75, Project Order No. 4. Project coordinator was Mr. Jerome Peterson of OCE.

The investigation was conducted from March 1974 to January 1975 by personnel of the Hydraulics Laboratory (HL), U. S. Army Engineer Waterways Experiment Station (WES), under the direction of Mr. H. B. Simmons, Chief of HL, Dr. R. W. Whalin, Chief of the Wave Dynamics Division, and Mr. D. D. Davidson, Chief of the Wave Research Branch. Messrs. A. W. Garcia, Research Oceanographer, and J. R. Houston, Research Physicist, both of HL, conducted the study, and this report was prepared by Mr. Houston with the aid of Mr. Garcia.

A significant portion of the numerical computations was performed on a CDC-7600 computer at the Los Alamos Scientific Laboratory through the cooperation and under the supervision of Dr. Kenneth Olsen of Group J-9. Also, Mr. H. L. Butler of the Harbor Wave Action Section, WES, provided valuable assistance in the performance of these calculations. Drs. Dean McManus and Warren Thompson of the University of Washington and the U. S. Naval Postgraduate School, respectively, provided unpublished data which greatly aided in the performance of this study, as did the staff of the National Ocean Survey, National Oceanic and Atmospheric Administration.

Attendees of the Type 16 Flood Insurance Study Tsunami Coordination meeting held at the U. S. Army Engineer Division, South Pacific, Office in San Francisco, California, on 11 and 12 November 1974 are listed below.

Name	Affiliation
John Ritter	U. S. Geological Survey
Jerome Peterson	Flood Plain Management Services, Office, Chief of Engineers

Name	Affiliation
Robert Whalin	U. S. Army Engineer Waterways Experiment Station
Andrew Garcia	U. S. Army Engineer Waterways Experiment Station
James Houston	U. S. Army Engineer Waterways Experiment Station
Robert Cook	Flood Plain Management Services, South Pacific Division
Warren Viets	Flood Plain Management Services, South Pacific Division
Gerald Gardner	Flood Plain Management Services, Seattle District
Romain Repair	Flood Plain Management Services, San Francisco District
Bill McCaleb	Flood Plain Management Services, San Francisco District
Scott Terry	Flood Plain Management Services, Los Angeles District
Orville Magoon	Coastal Engineering Branch, South Pacific Division
Henry M. DeGraca	Navigation and Shoreline Planning, San Francisco District
Benjamin Wells	Engineering Division, Water Resources Branch, San Francisco District
Claude Wong	Coastal Resources Branch, Los Angeles District
Bob Easley	Hydrologic Engineering Branch, South Pacific Division
Bob Edminsten	Coastal Engineering Branch, South Pacific Division

Director of WES during the investigation and the publication of this report was COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

TYPE 16 FLOOD INSURANCE STUDY: TSUNAMI PREDICTIONS FOR MONTEREY AND SAN FRANCISCO BAYS AND PUGET SOUND

PART I: INTRODUCTION

1. This study was conducted to determine 100- and 500-yr runup due to tsunamis of distant origin for parts of Monterey Bay, San Francisco Bay, and the Straits of Juan de Fuca and Puget Sound (Table 1). A 100-yr runup is one that is equaled or exceeded with an average frequency of once every 100 yr; a 500-yr runup has a corresponding definition. Runup values in this report are referenced to the mean sea level (msl) datum. = NGVD 1929

2. A finite-difference numerical computer program was used to simulate tsunamis and propagate them across the deep ocean to the mouths of the above-mentioned water bodies. The governing equations used in the program were the linearized long-wave equations. In order to simulate the generation of a tsunami, an uplift deformation of the water surface at a selected tsunami source site was used as an initial condition in the finite-difference program. As discussed in Reference 1, the large size of the generation areas considered and the short time interval during which displacement occurs cause the water surface deformation to display the same topographic features as the permanent vertical displacement of the ocean floor resulting from the earthquake.

3. The responses of San Francisco Bay and the Straits of Juan de Fuca and Puget Sound to an incoming tsunami were determined using a computerized numerical scheme which employs a finer spatial mesh grid than that used in the numerical scheme for propagating the tsunami across the deep ocean. This numerical solution cannot be validly applied to Monterey Bay, however, because this bay has a mouth that is wide relative to the length of the bay. Therefore, an analytic solution in the form of a standing wave for the linearized long-wave equations was used to propagate a tsunami across the continental shelf of Monterey Bay.

4. Although tsunamis are generated in many areas along the perimeter of the Pacific Basin, only the Aleutian Trench generates tsunamis

capable of causing significant runup in the study areas of this report with sufficient frequency to influence 100- and 500-yr runup values. Historical evidence, tsunami source characteristics and orientation, and numerical computer programs discussed in Reference 1 were used in the selection of the Aleutian Trench as the sole tsunamigenic area. The hypothetical uplift of the water surface used and the dimensional parameters which can be varied to represent tsunamis of different intensities in the selected tsunamigenic areas were also formulated therein.

5. The probability of generation of tsunamis of different intensities and the maximum height of the uplift deformation for the standard source were defined for these different intensities in Reference 1. The Aleutian Trench was divided into 12 segments and the wave amplitudes resulting from locating sources of varying intensities in each of the segments were calculated for points near the mouths of the bays considered. The responses of the bays were determined by the numerical and analytical solutions mentioned earlier. Each wave amplitude inside the bays has an associated probability, and the totality of wave amplitudes defines a probability distribution from which the cumulative probability distribution for a wave amplitude being greater than or equal to a particular value is obtained. Runup is set equal to wave amplitude at the shore.

6. A cumulative probability distribution, $P(z)$, for runup at a given site being equal to or exceeding a particular value due to the astronomical tide and a tsunami was determined using an approach discussed in Reference 1. This approach makes use of the following relationships:

$$P(z) = \int_{-\infty}^{\infty} f_\beta(\lambda) P_S(z - \lambda)\, d\lambda \tag{1}$$

where $f_\beta(\lambda)$* is the probability for the astronomical tide.

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* For convenience, all unusual symbols used in this report are listed and defined in the Notation (Appendix A).

This equation was solved numerically by superimposing tsunami wave trains on the tides for a 1-yr period.

7. A previous San Francisco Bay tsunami study of the U. S. Geological Survey is discussed and results are compared herein.

PART II: LOCATION AND USE OF BACKUP DATA

8. The numerical calculations used in determining the runup values will be retained at the U. S. Army Engineer Waterways Experiment Station (WES) for an indefinite period of time. These calculations by themselves are of limited usefulness in direct determination of runup at a particular coastal site because each raw calculation applies only to a specific intensity tsunami originating at a particular source. Probability distributions, tide analyses, and local effects are calculated using these data but they comprise a number of different and subsequent operations.

9. The user of the information contained in this report will have to judge for his purposes the adequacy of topographic information displayed within, i.e. the accuracy and spacing of contour intervals, the currentness of indicated features, etc.

PART III: EXPLANATION OF RESULTS

10. Table 2 lists the names of the topographic quadrangles contained in this report by groups, according to their geographical location. Because of the geographic complexity of the Monterey and San Francisco Bays and Puget Sound areas, it was not feasible to arrange the section of quadrangles in a continuous sequence following the shoreline of the areas. It was decided instead to arrange the quadrangle sections into subgroups by alphabetical order. Figures 1a and 1b are sections of indices to topographic maps of California and Washington, respectively. To locate the applicable subgroup of quad-sections, locate the area of interest in Figure 1a or 1b; these figures give the name of the topographic quad. The figure number for each quad can be found by referring to Table 2.

11. Located within each figure (Figures 2-239) is the estimated runup with the appropriate subscript designating the runup due to a 100- and 500-yr tsunami. It is specified in the form

$$R_{100} = \_\_ \text{ ft}$$
$$R_{500} = \_\_ \text{ ft}$$

The datum for all runup computations (R_{100} and R_{500}) is msl. As in Reference 1 the runup estimates will be applicable to those reaches of coastline indicated between the solid lines extending from the shoreline. Where only one pair of runup values is displayed, those values will apply to the entire reach of coastline shown in that figure.

12. The figure titles also follow the form used in Reference 1 but the explanation will be repeated here for the convenience of the reader. Using Figure 2 as an example:

Figure 2 - figure number.
Marina - name of topographic quadrangle from which illustration was taken.
Calif. - state in which area is located.
53+N to 57+N - digits indicating the 100-metre* Universal Transverse Mercator grid ticks used to delineate the

* 3.2808 converts metres to feet.

approximate boundaries of the section of quadrangle illustrated. (Letter following digits will be either N or E indicating north-south directed or east-west directed tick marks, respectively. A plus (+) or minus (-) sign indicates that the illustration extends slightly beyond or falls slightly short of the indicated tick mark.)

L - last letter indicating which boundary of the topographic quadrangle the grid tick marks are referenced to, i.e. R-right, L-Left, T-top, B-bottom.

Unless otherwise indicated, the scale of all the topographic figures is 1:24,000

PART IV: METHODOLOGY FOR RUNUP PREDICTIONS

Tsunami Sources

13. As described in Reference 1, the Aleutian Trench is divided into 12 segments. Ground displacements which produce tsunamis with intensities ranging from 2 to 5 in intensity increments of 1/2 are centered at the midpoint of each segment. As discussed in Reference 1, an investigation of tsunamigenic sites in the Pacific indicates that tsunamis generated along the Aleutian or Peru-Chile Trenches only cause significant runup along the western coast of the United States. Furthermore, it was found that the 100- and 500-yr runup values for the study areas reported herein are determined by tsunamigenic sites in the Aleutian Trench alone and are not significantly influenced by tsunamis generated in the Peru-Chile Trench.

14. As stated previously, a computer program for a finite-difference numerical scheme was used in Reference 1 to generate a tsunami (using a given ground displacement as input) and to propagate it across the deep ocean. The linearized long-wave equations were the governing equations in the program. This program uses a commonly available tape which contains bathymetric data at intervals of 1 deg of latitude and longitude. The program then interpolates these data to create another bathymetric grid for computational purposes that has 15 bathymetric data points per degree of latitude and longitude. While this procedure is adequate for those regions of the ocean that are relatively featureless, it is not satisfactory for wave propagation across the continental rise and portions of the continental shelf. To avoid this difficulty, the program was modified to include bathymetric data obtained from National Ocean Survey bathymetric charts. These data were smoothed from a minimum of 180 points to 15 points (compatible with the grid used for computation) per degree of latitude and longitude. This was done for both the previous[1] and present studies.

15. The program was used in this study to propagate tsunamis to the vicinities of Monterey and San Francisco Bays and the Straits of

Juan de Fuca. Local bathymetric irregularities (shoals and channels, for example) which might not be resolved by the large mesh grid covering part of the Pacific Ocean near the continental shelf, along with non-linear terms and vertical accelerations which are neglected in the linearized long-wave equations, produce effects which must be determined by calibration. Results of a computer simulation of the generation and propagation of the 1964 Alaska tsunami were compared with tide gage records obtained near the mouths of San Francisco Bay and the Straits of Juan de Fuca; differences in comparison are attributed to these local bathymetric irregularities and the neglected terms in the equations of motion. In this manner, the simulation of the 1964 tsunami was calibrated to reproduce the effects observed at the bay mouths.

Bay Response

16. Once the tsunami wave amplitudes at the mouths of San Francisco Bay and the Straits of Juan de Fuca were known, the responses of these partially enclosed bodies of water to the incoming tsunami were determined by using a computerized numerical scheme[2] which employs a fine mesh spatial grid. The numerical method used is that described by Leendertse.[3] Variable bathymetry and Chezy frictional coefficients in the bay were allowed as input to the program. The ratio of tsunami amplitude to water depth in parts of the bay is great enough that non-linear advective terms may be significant and are therefore included in the equations of motion. The period of the tsunami waves entering the bays was chosen to be 38 min for San Francisco Bay and 1.8 hr for Puget Sound; these periods were observed during the 1964 tsunami.[2] The reasons different locations can observe different tsunami wave periods are discussed in Reference 1.

17. The numerical solution discussed above cannot be validly applied to Monterey Bay because this bay has a mouth that is wide relative to its length. Wave recordings of the 1964 tsunami obtained at Monterey, California, indicate that resonance of the bay resulting from tsunami excitation is not significant in determining the maximum

runup; a number of major waves of approximately the same amplitude were observed during the 1964 Alaska tsunami.*

18. The analytical solution employed in Reference 1 to determine the modification of a tsunami after its propagation across the continental shelf was used at Monterey Bay to determine runup. A computer simulation of the generation and propagation of the 1964 tsunami across the deep ocean was coupled with the above analytical solution and the results were compared with gage recordings of the 1964 tsunami at Monterey to calibrate the techniques.

Effect of Astronomical Tides

19. As mentioned earlier, the statistical effect of astronomical tides on tsunami runup was determined in Reference 1 by an analytical solution of the convolution integral.[4]

$$P(z) = \int_{-\infty}^{\infty} f_\beta(\lambda) P_S(z - \lambda)\, d\lambda \qquad \text{(1 bis)}$$

where

z = the runup at any time above local mean sea level

$P_S(z)$ = the cumulative probability distribution for runup at a given site being equal to or exceeding z due only to the maximum wave of the tsunami

$P_\beta(z)$ = the probability of the runup at the same location being equal to or exceeding z due only to the astronomical tide, here approximated by a Gaussian distribution (tidal runup equals the tidal level)

$P(z)$ = the cumulative probability distribution for runup at a given site being equal to or exceeding z due to the maximum wave of the tsunami and the astronomical tide

and where

$$f_\beta(z) = -\frac{dP_\beta(z)}{dz}$$

* Prof. W. C. Thompson, personal communication.

and $f_\beta(z)$ is the probability density for the astronomical tide.

20. Tsunamis arriving at Monterey Bay, San Francisco Bay, and Puget Sound have, in the past, exhibited characteristic wave trains consisting of a number of waves of significant amplitude. The statistical effect of astronomical tides on tsunami runup for such a situation when more than a single maximum tsunami wave is important must be determined through a numerical solution because an analytical solution is intractable. A numerical approach similar to that used by Petrauskas and Borgman[5] to randomly combine the effects of astronomical tides and tsunamis recorded at Crescent City, California, was used to solve this problem. Data obtained during the 1960 and 1964 tsunamis were combined with tides at random times during a year by Petrauskas and Borgman. In this study, the combination at random times during a year of a wave train consisting of a specified number of waves of equal amplitude and period and the astronomical tides was considered. The amplitudes of the wave trains are not fixed, however, but are specified by probability distributions.

21. A time history of the tide for a year at any location of interest was determined by a computer program which used the techniques of Reference 6 and tide information from Reference 7. The period and number of significant waves of a tsunami which could be expected at a site were determined by analyzing wave records obtained during the 1964 tsunami. It is assumed here that the number and period of waves observed during the 1964 tsunami are indicative of the respective response of these areas to other high-intensity tsunamis. Five waves with a period of 38 min were chosen for the tide effect analysis for San Francisco Bay, three waves with a period of 1.8 hr for Puget Sound, and ten waves with a period of 36 min for Monterey Bay.

22. A tsunami with an intensity between 2 and 5 in increments of one-half is generated in one of the 12 segments of the Aleutian Trench and arrives at a site on the western coast of the United States with its significant waves having an amplitude which can be determined by the techniques described earlier in this report. The probability of such an event occurring is equal to the probability of a tsunami of some particular intensity being generated somewhere in the Aleutian Trench, given by

$$n(i) = 0.065e^{-0.71i} \tag{2}$$

multiplied by 1/12, because it is assumed that earthquakes occur uniformly throughout the length of the 12-segment trench.[1,8]

23. Each of the possible tsunami wave trains of intensity range 2-5 from 1 of the 12 segments is then superimposed upon the astronomical tide occurring at a site during a year. For example, the 10 significant wave crests of period 36 min of a tsunami arriving at Monterey Bay are superimposed on the tides over a 360-min interval; the maximum tsunami plus tide elevation for the period is assigned a probability equal to 1/12 multiplied by Equation 2, for a particular intensity i, multiplied by q (360 min/number of minutes per year = 6.85×10^{-4}). The tsunami is superimposed upon the astronomical tide for 360-min intervals for the entire year. By following this procedure for all tsunamis of intensity 2-5 for the 12 segments, a cumulative probability distribution for runup at a given site equal to or exceeding some value due to the superposition of the tsunami and the astronomical tide was determined. The 1 in 100-yr and 1 in 500-yr runup values at a site were determined from this probability distribution.

Results

24. By applying the methodology described in the previous sections and in Reference 1, 100- and 500-yr runup values were calculated for Monterey Bay, San Francisco Bay, and the Puget Sound area. The runup values (referenced to msl) are shown in Figures 2-239 which are sections of topographic quadrangle maps published by the U. S. Geological Survey.

25. The effect of the astronomical tides on runup varied from location to location. The more pronounced the tidal range, the more significant was the increase in runup due to the influence of the astronomical tides. For example, tsunami waves in Puget Sound had small amplitudes, and runup values were governed largely by the effect of astronomical tides. Therefore, although waves had larger amplitudes at Port Townsend, Washington, than at Seattle, Washington, the greater

tidal range at Seattle resulted in larger combined runup values there.

26. The effect of the astronomical tides on runup was also dependent upon the probability distribution of tsunami wave amplitudes at a location. The tidal contribution to runup is usually greater for locations protected from tsunamis than for those exposed. This can readily be seen for an analytic solution of Equation 1.

27. For simplicity consider only a single source region (e.g. the Aleutian Trench) and let $P_S^{(1)}(z)$ be represented by an exponential function

$$P_S^{(1)}(z) = A_1 e^{-\alpha_1 z} \tag{3}$$

where the superscript (1) denotes location 1.

28. Suppose that tsunamis at a second location occur with the same frequency as that for the first location but always produce twice as great a runup. Then

$$P_S^{(1)}(z) = P_S^{(2)}(\hat{z}) \tag{4}$$

where

$$\hat{z} = 2z$$

and

$$P_S^{(2)}(\hat{z}) = A_2 e^{-\alpha_2 \hat{z}}$$

$$= A_2 e^{-2\alpha_2 z} \tag{5}$$

Therefore

$$A_1 e^{-\alpha_1 z} = A_2 e^{-2\alpha_2 z}$$

$$A_1 = A_2 \quad \text{and} \quad \alpha_1 = 2\alpha_2 \tag{6}$$

29. In Reference 1 it was found that the net effect of the astronomical tide is to produce a $P(z)$ identical with $P_S(z)$ except for a shift of z by an amount $(\sigma^2/2)\alpha$. σ^2 is the tidal variance and equals $\sum_{m=1}^{\infty} C_m^2$ where C_m is equal to the m^{th} tidal constituent. To

evaluate Equation 1

$$P_\beta(z) \approx f_\beta(z) = \frac{1}{\sqrt{(\pi\sigma)}} e^{-z^2/2\sigma^2}$$

30. Since σ^2 varies very little between two locations, the effect of the astronomical tide on runup is approximately twice as large for location 1 as for location 2.

31. As an example of this effect note that although a tsunami at the easterly end of San Pablo Bay in San Francisco Bay is reduced to less than one-tenth its height at the Presidio, the 100-yr runup including the effect of astronomical tide is reduced only by a factor of between 2 and 3.

San Francisco Bay Tsunami Study by the U. S. Geological Survey

32. An earlier study of tsunami runup in the San Francisco Bay region was performed in cooperation with the Department of Housing and Urban Development by John R. Ritter and William R. Dupre of the U. S. Geological Survey of the Department of the Interior.[9] This previous investigation determined a 200-yr tsunami runup at the Presidio in San Francisco (Figure 240) by extrapolating a frequency of occurrence curve for the maximum tsunami waves at the Presidio which was developed by Wiegel[10] and based on historical data for the years 1900-1965. Tsunami attenuation inside San Francisco Bay was based on data of the May 1960 and March 1964 tsunamis collected by Magoon.[11] The maps of this earlier study delineated areas which would be subject to inundation in the event of a 200-yr tsunami occurring during the mean higher high water tidal stage.

33. The 100-yr tsunami maximum wave height predicted by the extended frequency curve (Figure 2 of Reference 9) is approximately 11 ft.* The ordinate axis of this graph is erroneously labeled "Maximum

* 0.3048 converts feet to metres.

Wave Height or Runup." Wiegel[10] plotted maximum wave height versus recurrence interval for Crescent City and San Francisco, California. Runup was plotted versus recurrence interval for Hilo, Hawaii, in the same figure. The word "Runup" was intended to be the ordinate axis label for Hilo only. Maximum wave height in this case refers to what is sometimes called range, the sum of runup plus drawdown, and thus runup does not refer to wave height.

34. Assuming that tsunami waves are approximately sinusoidal (as noted by Wilson,[12] the 100-yr tsunami would have an amplitude of 5.5 ft at the Presidio according to Ritter and Dupre's analysis. Neglecting tidal effects, this is a 5.5-ft runup above mean sea level. The 100-yr runup at the Presidio calculated in this report is 7.0 ft (predictions in Figure 54 include tidal effects) above mean sea level if tidal effects are neglected. The Geological Survey analysis also predicts a 500-yr runup of 15 ft. This compares with a 14.6-ft runup value, neglecting astronomical tides, calculated in this report.

35. Tsunami attenuation inside San Francisco Bay as calculated in this report is similar to the attenuation noted by Magoon (Reference 11) for the May 1960 and March 1964 tsunamis. The tsunami wave amplitude at Richmond on the north and Hunter's Point on the south is approximately half the height at the Presidio. The attenuation noted by Magoon and the attenuation calculated in this report are compared in Figure 240b.

36. The numerical method used herein allows prediction of tsunami runup in San Francisco Bay over an area bounded laterally by Point San Pablo on the north and Point San Bruno on the south. The limits of these boundaries are dictated by a combination of small grid size required to adequately define the incoming wave at the bay entrance and maximum storage available using the WES Honeywell 635 computer. It is doubtful that the numerical technique used would give meaningful results in very shallow areas of the bay because the tsunami wave height becomes a significant fraction of the water depth. For those areas of the bay not covered by the numerical grid, the tsunami wave was linearly decayed with distance from the values at the boundary of the numerical grid to

the normalized value of 0.1 at the ends of the bay. The fact that the numerical grid did not include the entire San Francisco Bay is not felt to be a deficiency with serious consequences because the wave has decayed to less than half its height in the distance from the bay entrance to the boundaries of the numerical grid.

Conclusions

37. The resonance problem of Monterey and San Francisco Bays has required particular attention and individual treatment. The physical configuration of these bays is such that similar techniques could not be used for both. For example, while San Francisco Bay is characterized as being very elongated with a relatively small mouth, Monterey Bay is more or less semicircular with a relatively wide mouth. Moreover, Monterey Bay is bisected by a deep submarine canyon which effectively partitions it into separate basins.[13] In contrast, the overall problem in the Straits of Juan de Fuca and Puget Sound is not primarily one of resonance but of the decay of the leading waves of the tsunami as they progress along a narrow body of water.

38. The adoption and modification of techniques described by Petrauskas and Borgman[5] for combining tsunami and astronomical tide effects permits a series of waves (of the same tsunami) to arrive at different times during a tidal cycle; in contrast, an earlier report[1] allowed only the leading wave (assumed to be the largest) to be combined with the astronomical tide. This approach results in greater accuracy, especially in areas in which the tsunami is small relative to the tidal range.

39. Use of the latest (in some instances unpublished) bathymetric information for the Pacific coast of the United States allowed significant improvement in the detailing of the coastline and continental shelf area. The finite difference numerical program normally interpolates information available from the 1-deg-square bathymetric tape from one point per square degree to nine points per square degree. However, for this area, the interpolation process was not used; instead,

bathymetric data compatible with the numerical program were inserted.

40. For the three areas considered, analysis of the error attributed to each of the various steps in the procedure results in an estimated maximum average uncertainty of about ± 40 percent.

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Table 1

Areas Definitely Included or Excluded

Included	Excluded
Monterey Bay	
Santa Cruz Harbor and Small Craft Harbor	Salinas River
Monterey Harbor	Pajaro River
The beaches of Monterey Bay extending from Pt. Pinos to Pt. Terrence	Moss Landing Harbor
San Francisco Bay	
San Pablo Bay	Carquinez Strait
San Francisco Bay	Napa River
Richardson Bay	Petaluma River
Golden Gate as far seaward as Pt. Bonita and Pt. Lobos	Sonoma Creek
	Redwood Creek
Straits of Juan de Fuca, Puget Sound	
Seattle and vicinity	Hood Canal
Tacoma and vicinity	Saratoga Passage
Victoria and vicinity	Skagit Bay and Holmes Harbor
Everett and vicinity	Port Susan
Port Angeles and vicinity	Sooke Harbor
Port Townsend	

Table 2

Topographic Quadrangles

Quad Name	Applicable Figure No. (Inclusive)
Monterey Bay	
Marina	2-5
Monterey	6-7
Moss Landing	8-11
Santa Cruz	12-13
Sea Side	14
Soquel	15-17
Watsonville W.	18-19
San Francisco Bay	
Benicia	20
Hunters Point	21-23
Mountain View	24-26
Newark	27-28
Oakland E.	29
Oakland W.	30-35
Petaluma Point	36-40
Redwood Point	41-47
Richmond	48-50
San Francisco N.	51-57
San Francisco S.	58-60
San Leandro	61-65
San Mateo	66-68
San Quentin	69-76
San Rafael	77-78
Sears Point	79
Puget Sound Area	
Anacortes	80-81
Angeles Point	82-84
Bremerton E.	85-88
Camano	89
Cape Flattery	90-91
Clallam Bay	92-93
Coupeville	94-95
Deception Pass	96-99

Quad Name	Applicable Figure No. (Inclusive)
Puget Sound Area (Continued)	
Des Moines	100-103
Disque	104-105
Dungeness	106-110
Duwamish Head	111-117
Edmonds E.	118-119
Edmonds W.	120-123
Everett	124
False Bay	125-128
Freeland	129-132
Friday Harbor	133-138
Gardiner	139-144
Hansville	145-149
Joyce	150-151
Langley	152
Marysville	153-155
Maxwelton	156-159
Mukilteo	160-165
Nordland	166-171
Orcas Island	172-175
Port Angeles	176-177
Port Gamble	178-182
Port Townsend	183-187
Port Townsend S.	188-189
Port Townsend N.	190-192
Poverty Bay	193-194
Pysht	195-196
Richardson	197-199
Roche Harbor	200-203
Seattle N.	204
Seattle S.	205-206
Sequim	207-210
Shilshole Bay	211-216
Suquamish	217-220
Tacoma N.	221-228
Tulalip	229-232
Twin River	233-234
Vashon	235-239

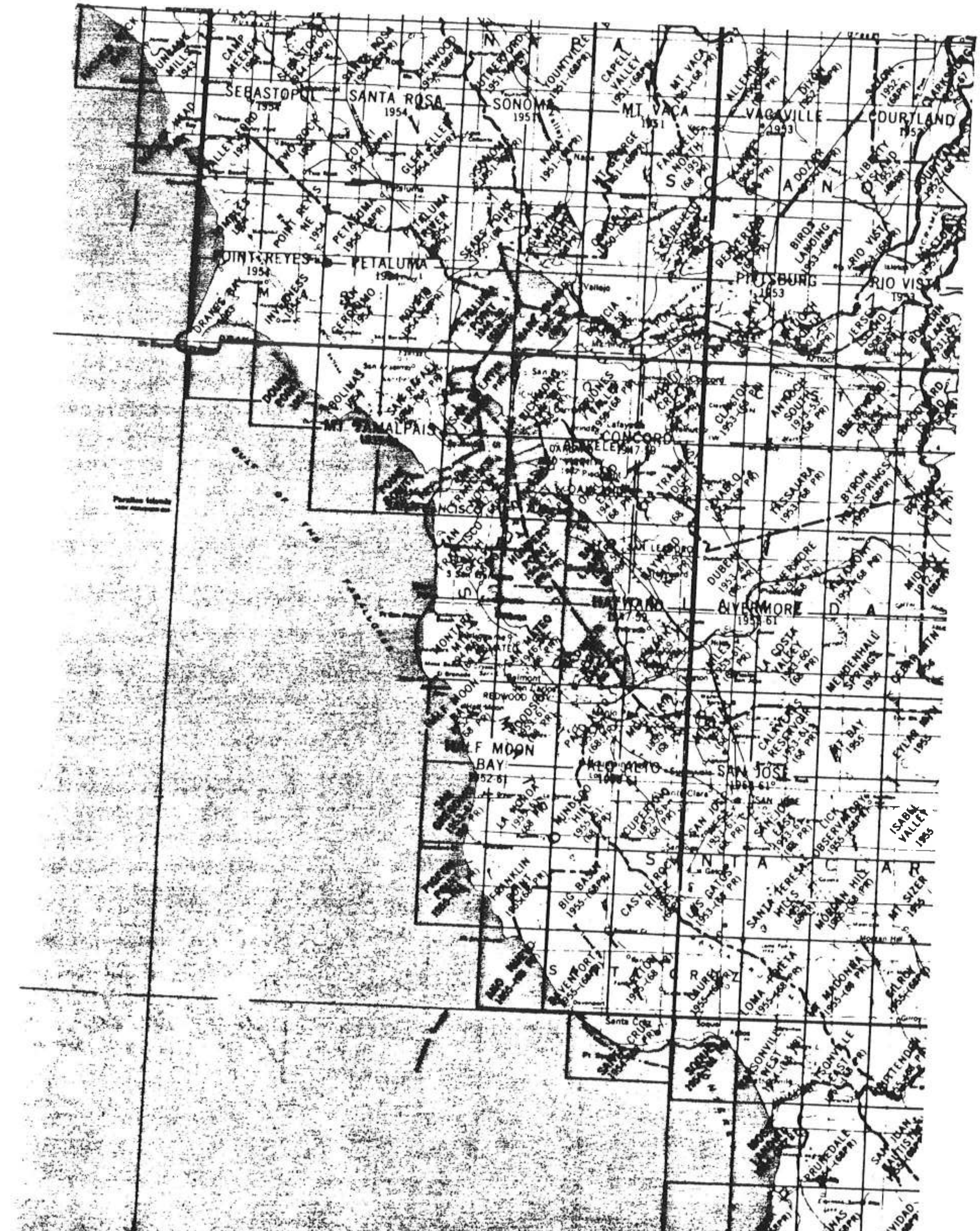

Figure 1a. Portion of index to topographic quadrangles of the State of California

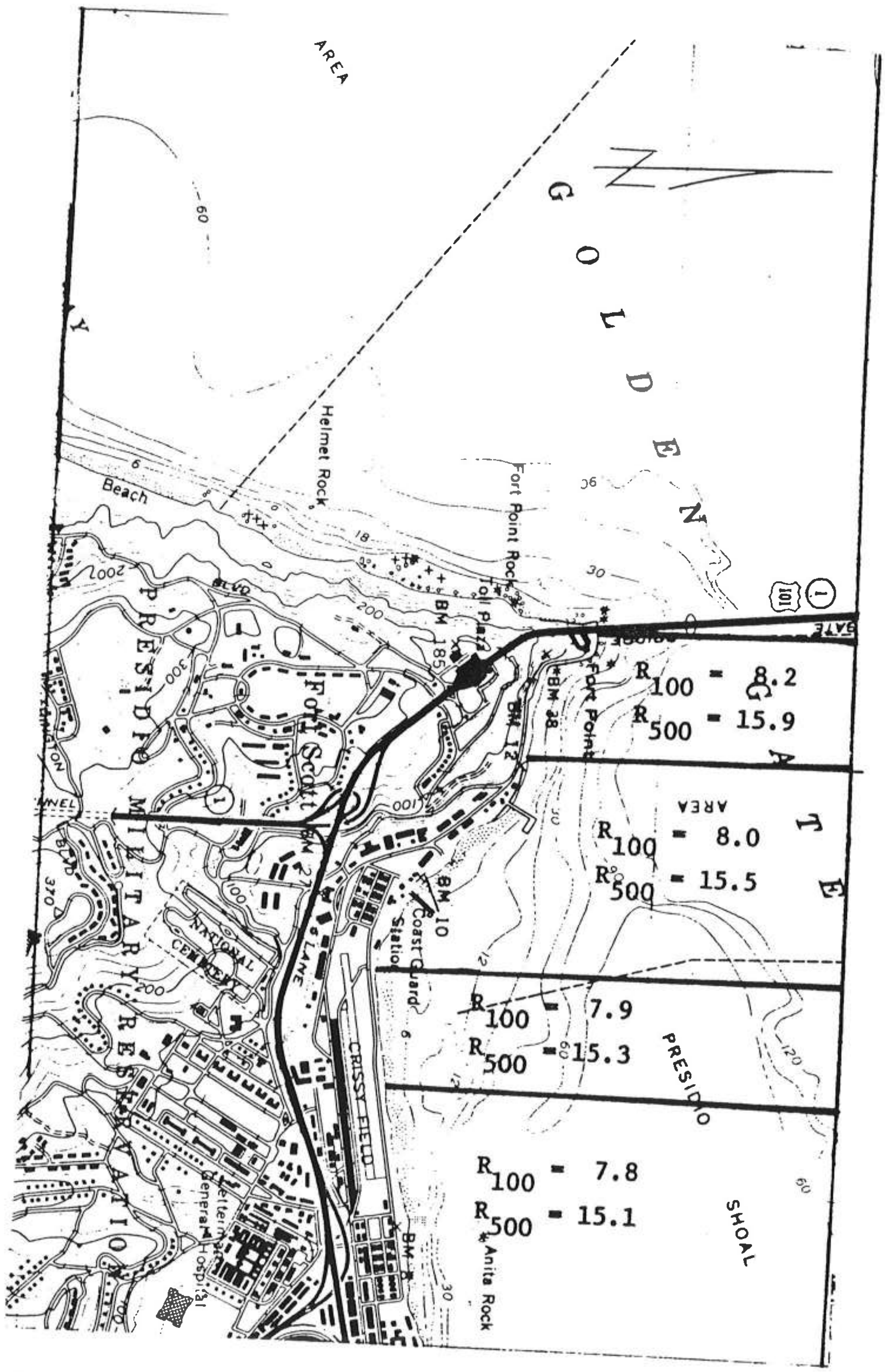

Figure 54. San Francisco North, Calif., 82+N to 85+N, L